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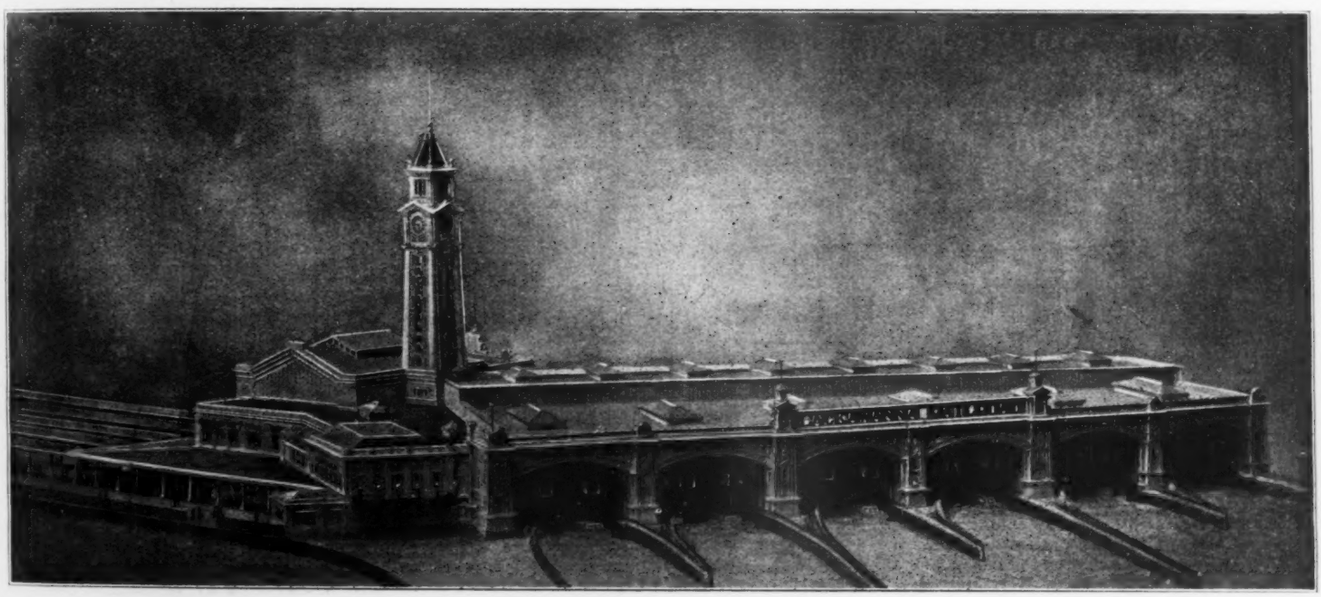
THE NEW TERMINAL STATION AND FERRYHOUSE OF THE DELAWARE, LACKAWANNA & WESTERN R. R. AT HOBOKEN, N. J.

By Charles C. Hurlbut.*

The new terminal and ferryhouse of the Lackawanna Railroad at Hoboken, N. J., now in course of construction, is a fireproof structure erected entirely over water and possesses some features unique in buildings of this class. The architectural effect of the new terminal may be gathered from the adjoining halftone view, the photograph of a complete model of the structure; the view is from the southeast, thus showing the ferry front of the building.



GENERAL VIEW OF NEW TERMINAL OF DELAWARE, LACKAWANNA & WESTERN R. R. AT HOBOKEN, N. J.
(From photograph of a model.)

The chief points of interest from an engineering and architectural standpoint are the concrete foundation supported on piles; the steel and concrete construction of the superstructure, designed with a special view to the resistance to shock and unequal settlement; the very extensive use of copper as an exterior finish and its mode of application, and the methods of erection necessitated by the conditions of traffic.

GENERAL PLAN.

The plan was controlled to a large extent by local conditions. About 600 ft. of the water front was available, bounded on the north by the steamship piers of the Hamburg American Line. As a large part of this frontage was occupied by the old terminal, through which about 100,000 people a day were passing, it was necessary to design the new building for construction in six consecutive sections, each of which could be opened for traffic before starting the succeeding one. A fire on Aug. 8, 1905, which totally destroyed the old terminal and ferryhouse, somewhat altered this plan, however, and the temporary buildings now in use were so placed as to facilitate the construction as far as possible. An elevated-track station was considered but rejected as impracticable owing largely to the steep grades that would be introduced by the position of the railroad yards and the tunnel through Bergen Hill, only a short distance away.

The number of passengers carried by the three ferries entering the terminal in the first six months of 1906 was 17,200,000, which means a daily average of 94,300. As the number carried on Sundays and holidays, however, is much less than on week-days, the week-day average is something over 100,000. Of this number something less than half are railway passengers, and the others are distributed by the trolley lines terminating at the station or pass direct to the street. The great bulk of this traffic is concentrated into a few hours in the morning and late afternoon. The ferryhouse provides for three separate ferry-lines, each with two slips, equipped for double-deck boats. To separate and prevent congestion of these many lines of traffic, to provide for rapid loading and unloading of boats, to make the entrance and exit of ferry-passengers as short and direct as possible, and (not least) to prevent "beating the ferry" were the main controlling factors in the plan of the ferryhouse portion of the terminal.

The requirements of the railroad station were: Ample waiting-room facilities for passengers waiting for trains and for boats, including provision for housing safely as many as 20,000 people at one time, which might become necessary in the event of the disability of the ferry for an hour or more in the morning rush hours; Restaurant, lunch-room and kitchen; Storerooms for the dining car and commissary departments; Offices for the division superintendent, train dispatchers, ferry superintendent, baggage master, auditor and other officials; besides a barber shop, toilets, hospital room and the other usual adjuncts of a terminal railroad station.

The disposition of space to meet these various requirements is clearly shown on the general plans reproduced in Fig. 2. Eastbound passengers from trains pass from the train concourse either (1) up a 10% incline just south of the Main Waiting Room, to the ferry concourse on the second floor and thence to the upper deck of the boats, or (2) through the eastbound waiting-room and team concourse to the lower deck of boats. Subsidiary waiting-rooms are provided on the first floor, for the convenience of passengers, between the ferry slips. Eastbound ferry passengers enter the ferry waiting-room and pass direct to the boats, or by means of stairs to the ferry concourse. Westbound passengers pass direct to the street by practically straight exits from the lower deck of boats; or, from the upper deck, enter the

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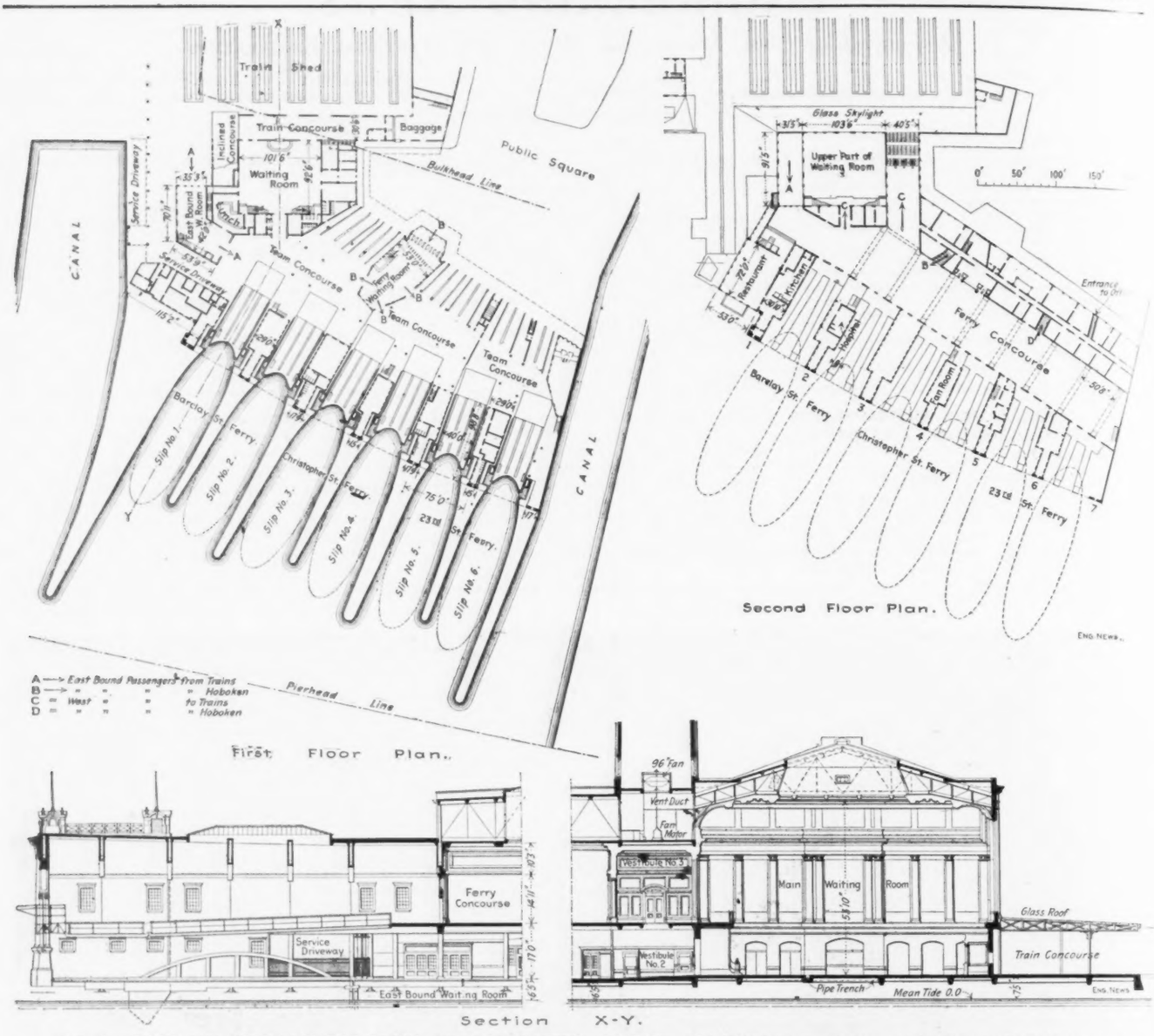


FIG. 2. FIRST AND SECOND FLOOR PLANS, AND LONGITUDINAL SECTION; LACKAWANNA TERMINAL STATION AT HOBOKEN, N. J.

(Note.—Upper Deck Landing Bridge Shown in Longitudinal Section is old type. See Fig. 13 for drawing of bridge actually used.)

ferry concourse, and thence pass to the street by easy stairways. Passengers to the trains go to the trainshed by way of the westbound concourse, which leads off the Ferry Concourse along the north of the main waiting room and terminates in a stairway 40 ft. wide, or pass into the main waiting-room by a marble staircase. Provision is made in the plan for a future arcade from the ferry concourse to the trolley terminus about 200 ft. away.

The main waiting-room for westbound (outgoing) train passengers is 90 ft. × 100 ft. in plan, and 53 ft. 10 ins. high, with large windows on all sides and a large skylight overhead. The ferry concourse is 70 ft. wide, 470 ft. long and 28 ft. 5 ins. high, lighted by large skylights. This concourse is flanked by rows of twin columns supporting deep beams which divide the main part of the concourse into seven panels, forming its most distinctive decorative feature. The restaurant is 72 ft. × 53 ft. The total river elevation is 566 ft. 2¼ ins. long. The train concourse is 307 ft. long and provides for fourteen tracks. The baggage room (for Hoboken baggage only. New York baggage being checked at the New York ferry terminals) is practically a separate building and opens on the train concourse.

The train concourse is entirely covered with a roof of wire glass supported on steel trusses and purlins. The sidewalk along the entire street front of the building is covered by a marquise of similar construction.

A two-story building to serve as immigrant station and as depot for the supply of Pullman cars is located at the head of the short canal just south of the main terminal. This building is indicated in the Second Floor Plan (in Fig. 2). The Service Driveway and the Immigrant Track are arranged with reference to the location of this building.

Structural and Ornamental Design.

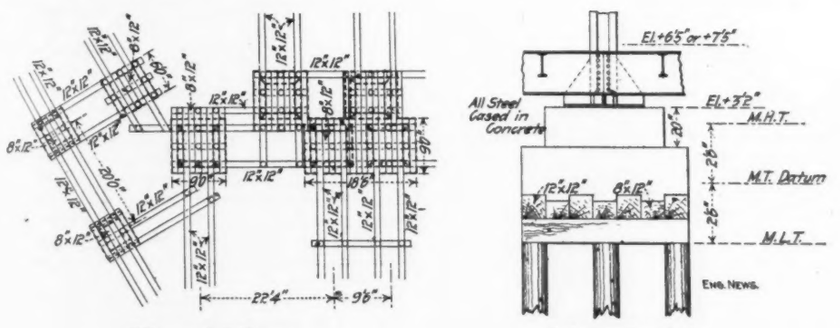
GRADES.—The floor level of the ferryhouse was fixed by the height of the first deck of the boats above the water under ordinary loading, namely 6 ft. 5 ins., and that level was therefore adopted as the general level of the ferryhouse floor. The level of the railroad station was determined by the height of the tracks, and that floor was accordingly fixed at 7 ft. 5 ins. above mean tide. The change from one grade to another is made by easy inclines. The level of the tops of piers is in all cases 3 ft. 2 ins. above mean tide. This is 8 ins. above high tide and as close to the floor construction as was possible and allow the necessary spread for the column bases.

ARCHITECTURAL DESIGN.—The most notable feature of the building as one approaches from the river is the clock tower, which rises to a height of 203 ft. above mean tide to the base of the flagpole. The six ferry slips are spanned by arches, supported by ornamental piers, as shown in the view on the preceding page. The base of the piers and also the base of the restaurant wing is of faced concrete; above this level the entire structure, including the tower, is covered with copper-work. The west or street elevation of the ferryhouse portion has five bays, surmounted by pediments, and is also of copper. The baggage room building and the first story of the north elevation of the railroad station are of Indiana limestone with copper-work above. The ornamental details of the copper-work were carefully studied with a view to preserve the character of the material and give a "metallic feeling" to the design. Details and moldings usual in stonework cannot be copied successfully in sheet-metal without modification, and all appearance of an attempt to imitate stone or other material was carefully avoided. The interiors will be finished for the most part in plaster and while not ornate in treatment will follow the modern French school. The first story walls of the main waiting-room are of buff limestone.

STRUCTURAL DESIGN.—The entire terminal building with the exception of the baggage room

wing is built over water of a depth of about 20 ft., overlying from 70 to 75 ft. of mud. Under the mud is a bed of sand and gravel of varying thickness, and rock is encountered at a depth of from 110 to 120 ft. below mean tide. The general requirements of the case called for a permanent, fireproof structure, sufficiently flexible to permit of slight inequality of settlement without serious damage and yet sufficiently rigid to withstand the shocks of the ferryboats, and as light as possible. The type decided upon was a riveted steel framework enclosed entirely in concrete. All the stresses are figured as taken up by the steel.

FOUNDATIONS.—The typical foundation is clearly shown in the vertical section in Fig. 3. Each column is supported on a group of from 9 to 25 piles of long leaf yellow pine from 80 to 90 ft. long. The pile loading is about 8 tons maximum. The piles are cut off at low water and capped with 12 × 12-in. timbers, upon which is laid a solid flooring of 12 × 12-in. alternating with 12 × 8-in. timbers. As the average height of tide (between high and low water) is 5 ft., the woodwork is entirely submerged about two-thirds of the time and is always wet, so that the danger of decay is eliminated. In the waters of the North River it is unnecessary to take precautions against the teredo or limnoria, as the presence of these pests has not been discovered in any piles driven in these waters within the last twenty years. This statement is based on the experience of the engineering departments of the Delaware, Lackawanna & Western R. R. and the New York City Department of Docks & Ferries; the fact is explained by the presence of sewage in the water. In each grillage as described above, two or more timbers of each course are continuous through two or more footings, as shown in the plan in Fig. 3. The footings are therefore securely tied together in two directions, effectually preventing any lateral displacement of any individual footing. The whole timber structure is securely bolted together. On the platforms described were built concrete piers which were leveled off for the columns 3.15 ft. above mean tide. Anchor bolts were built in to secure the columns, and under the heavier columns the concrete piers were reinforced with grillage of steel beams.



Piling and Grillage. Column Foundation.

FIG. 3. TYPICAL COLUMN FOUNDATION, AND PART PLAN OF PILING AND GRILLAGE, SHOWING METHOD OF TYING TOGETHER THE PIERS.

The foundation of the tower, Fig. 4, differs from this arrangement because the tower was designed to rest on a single foundation block in place of four separate footings, in order to avoid all risk of unequal settlement. The area covered by the tower foundation is closely piled and a two-course timber grillage built over the piles. The concrete pier constructed on this grillage extends to within 4 ins. of the finished floor, or 6 ft. 1 in. above mean tide; it encloses a steel grillage of two courses of I-beams, 15 and 24-in., securely tied together by steel angles and bolts. The four tower legs rest on the upper course of grillage beams, the column footing thus being imbedded in the foundation concrete.

All foundation piers (except that of the tower) are formed with offsets or shoulders around the outside, adapted to serve as a footing for hydraulic jacks to allow of raising the columns in case of undue settlement; for the same purpose inverted stiffeners were placed above the girder connections of the first floor, strong enough to take the entire dead load of the column above the first floor, except where the girder connection itself was strong enough to take this load. After placing the steelwork of the first section the column footings settled about ¾-in., and after the concrete of walls, floors and roof was placed a further settlement was found, ranging from ¼-in. to 2¼ ins. The tower foundations settled ¾-in. after placing the concrete pier; this was taken up with steel plates before setting the steelwork. After the erection of the steelwork a further settlement of ⅞-in. was found, uniform over the whole area of the tower base.

The general type of the foundations was developed by the writer, with the cooperation of Mr. E. W. Stern, the consulting engineer of the work. The pile loading was fixed by the engineering department of the railroad company, which also worked out the plans of the foundations in detail and carried out their construction, under Mr. Lincoln Bush, Chief Engineer.

FLOORS AND ROOFS.—The floors and roofs throughout the building are of reinforced concrete, Columbian type, supported on steel beams and girders with riveted connections. The beams are spaced from 5 ft. to 7 ft. on centers. The first floor is of stone concrete and the second floor and roof are of cinder concrete, both being mixed in the proportion 1:2½:5. The first floor of the ferryhouse and the service driveway are designed for a maximum concentrated load consisting of a truck weighing 15 tons on a 5 ft. × 10 ft. base. Other floors are designed for live loads of from 90 to 120 lbs. per sq. ft. It will be noted from the drawings that the first-floor girders are riveted to the columns and do not rest on the concrete footings, and as stated above these connections are in all cases made

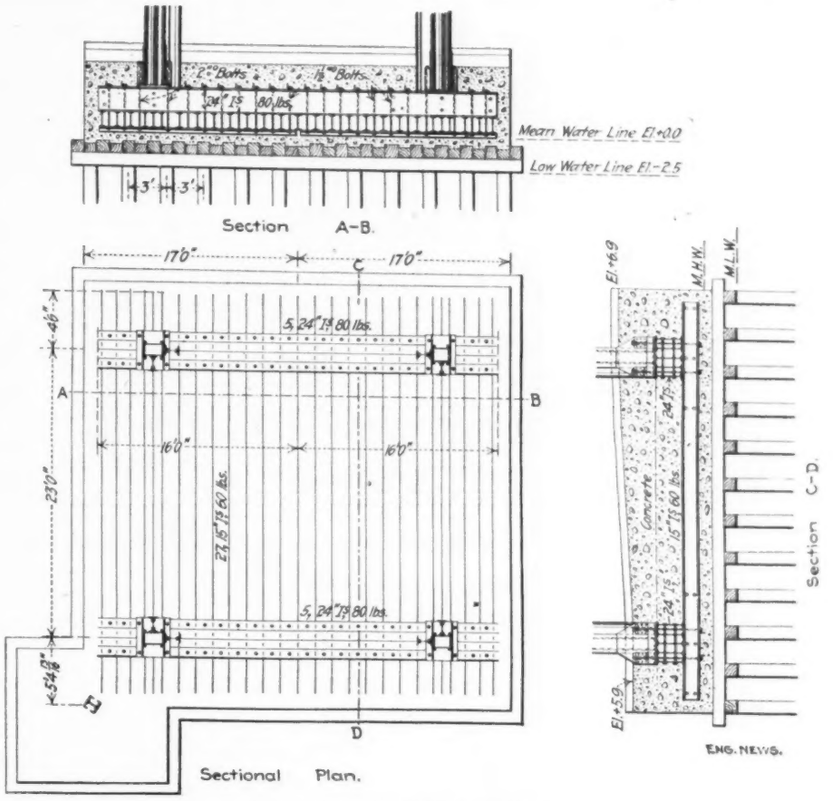


FIG. 4. FOUNDATION OF TOWER.

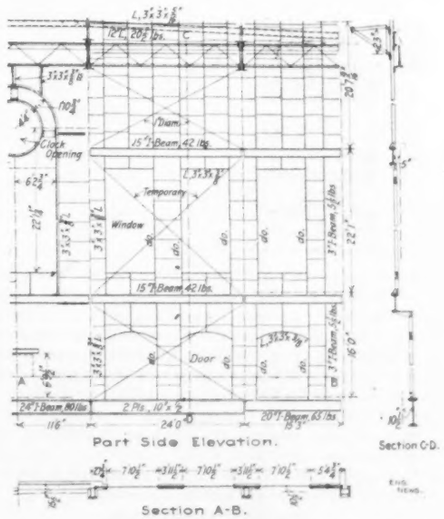


Fig. 5. Steel Studding of West Wall of Train Waiting-Room.

(This is typical of the wall-framing throughout the Terminal.)

sufficient to support the dead weight on the column.

WALLS.—The outside walls and the walls of the ferry slips and team concourse are 5 ins. thick, of cinder concrete reinforced with vertical 3-in. I-beams about 4 ft. on centers, which are bolted at the top and bottom to wall beams and are stiffened with frequent tie rods. Fig. 5 gives an idea of how this metal studding is arranged in the case of one of the large unstiffened walls. All openings are framed out with angle irons or 5-in. channels. The concrete bases of the river piers and the base of the restaurant wing consist of faced stone concrete and are considerably thicker. All the cinder-concrete walls are covered with sheet metal which is secured to the concrete by bolts passing entirely through the wall (nailing is not permitted); on outside walls this is 18-oz. copper, on other walls it is No. 22 galvanized iron siding of clapboard pattern. The construction of the minor partitions is noted farther on under Finishing Materials.

STEEL FRAMEWORK.

All the steelwork throughout the building, including the girders, beams, column bases and the cast-iron pedestals under the Main Waiting Room floor, and excepting only the main roof trusses, is entirely incased in concrete. The main roof trusses are protected from fire by suspended ceilings plastered with Portland cement mortar.

Fig. 6-a, giving a part plan of the framing, illustrates the general arrangement of the steelwork. A noticeable feature of the steel framework is the method of connection and bracing of trusses and girders. As stated above some irregularity of settlement must be looked for in a building of this area, and for that reason rigid connections were avoided as far as possible. The roof trusses in nearly all cases rest either on the tops of columns or on the top flange of longitudinal girders as illustrated in Figs. 6 and 7. The bracing is effected by heavy curved knee braces which resist as curved beams and not as struts, and will continue to act as braces even after some displacement of steel occurs due to settlement, whereas a rigid connection would be torn apart and fall utterly. The connection of the trusses over the main waiting-room is an exception to this rule (Fig. 8), as these trusses are riveted to the sides of the columns; but the length of the columns in that case is considered to offer sufficient flexibility.

Except in the tower, no diagonal framing is used in the walls, in order to carry out this scheme of flexibility. But abundant provision was made for temporary sway-bracing; connection plates for 1-in. diagonal rods riveted to the columns were provided (see Fig. 7) instead of letting the bracing during erection rely on makeshift connections. Sway-rods of 1-in. round steel were called for as part of the material, and the drawings called for connection-plates in a sufficient number of panels to make certain of early bracing no matter where the erection might be started.

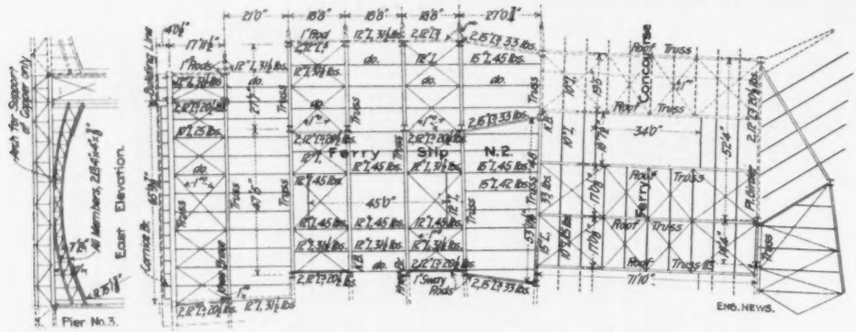


FIG. 6A. PART PLAN OF ROOF FRAMING OVER FERRY SLIPS AND FERRY CONCOURSE.

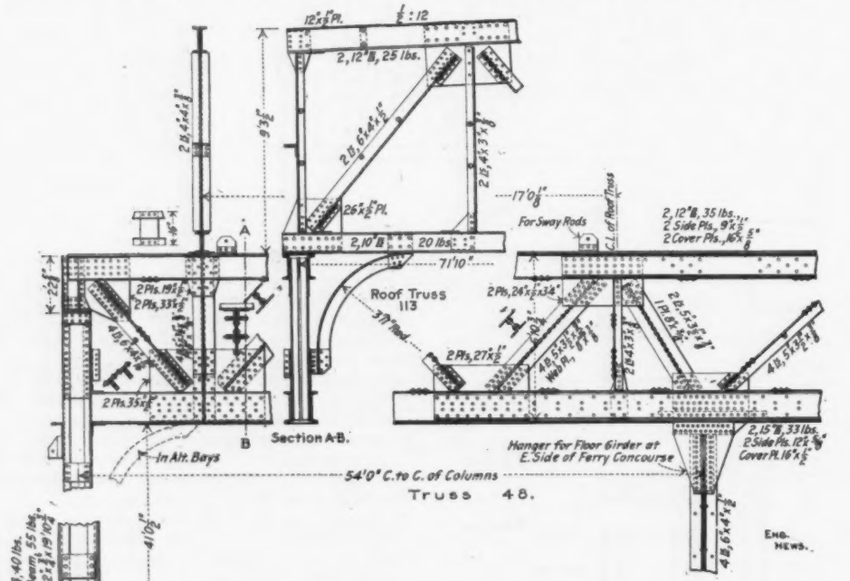
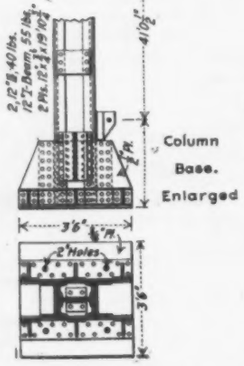


FIG. 6B. ROOF TRUSS OVER FERRY CONCOURSE AND LONGITUDINAL TRUSS BETWEEN FERRY SLIPS AND CONCOURSE.



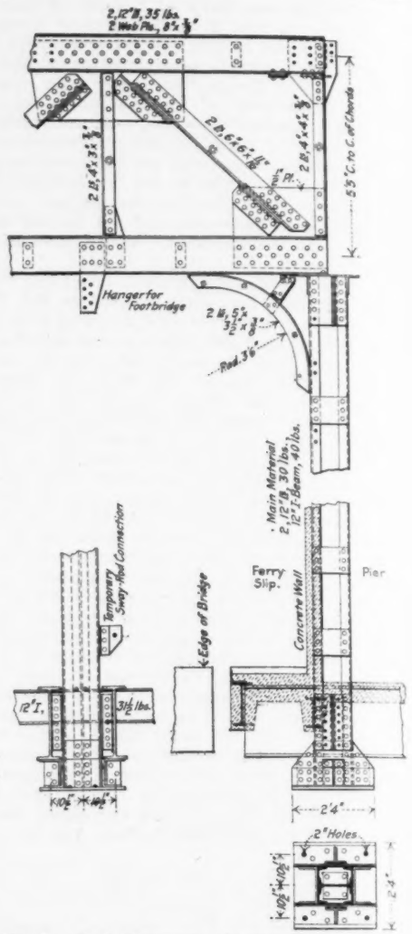


Fig. 7. Part Transverse Section of One of the Ferry Slips, Showing Steel Framing.

The tower, Fig. 9, is a steel skeleton covered with ornamental copper which is reinforced with small angles and bolted to the steelwork. The tower is not enclosed in concrete walls. It contains a clock and a 2,500-lb. bell; otherwise its purposes are purely ornamental. It is separated from the building proper by a concrete floor at the roof level.

The steelwork of the floors is generally simple. The special connections of the first floor girders

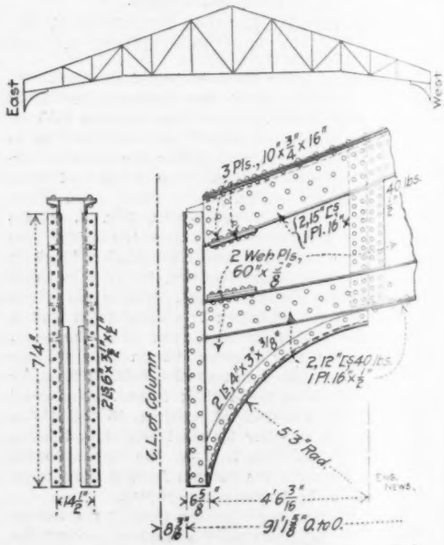


Fig. 8. End Section of Roof Truss Over Train Waiting-Room.

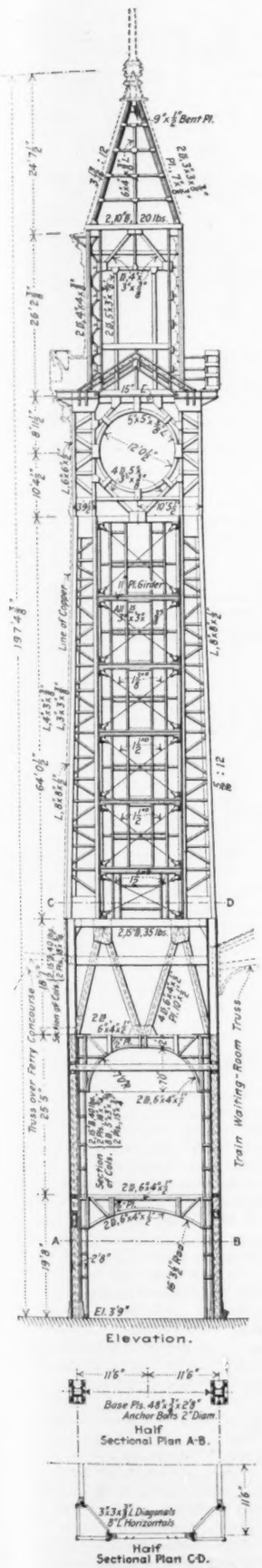


Fig. 9. Framing of Tower (North Elevation).

have already been remarked upon. Another feature worth noting occurs in the floor of the ferry-concourse, where long spans had to be bridged, as the team-concourse beneath could not be impeded by columns. Since head-room in the team-concourse was an important matter, it was necessary to contrive girders of the required span with a minimum depth. This was done by using a pin-connected cantilever construction for the main plate-girder which runs longitudinally under the ferry-concourse floor. Fig. 10 shows the construction used. This girder runs along the middle line of the ferry-concourse. The corresponding girders along the east line of the ferry-concourse, which have equally wide column spacing, do not require this unusual device, as they could be hung from the roof trusses above by a suspender, which halves the girder span (see Fig. 6-b).

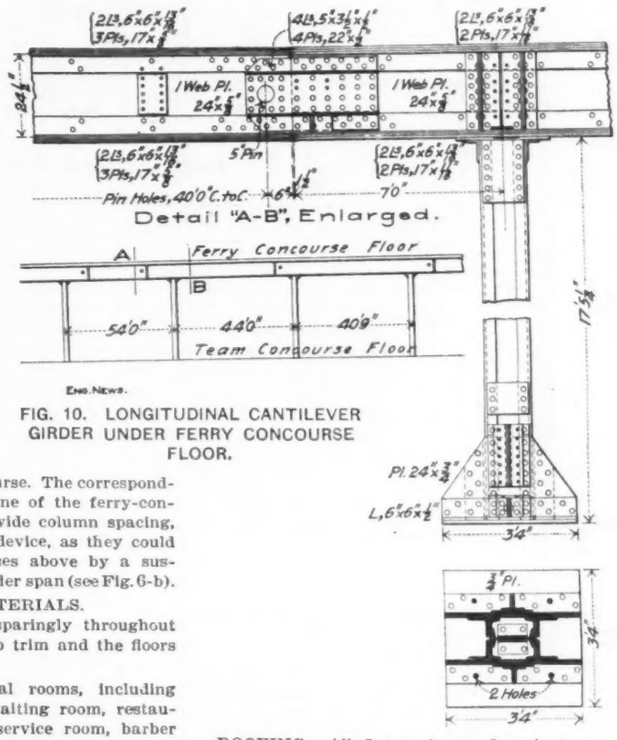


FIG. 10. LONGITUDINAL CANTILEVER GIRDER UNDER FERRY CONCOURSE FLOOR.

FINISHING MATERIALS.

Wood will be used very sparingly throughout the building, being limited to trim and the floors of offices.

FLOORING.—The principal rooms, including main waiting room, ferry waiting room, restaurant, lunch room, kitchen, service room, barber shop and the west bound and main ferry concourses, are floored with terrazzo. In the construction of these floors special attention is given to reducing the danger from cracks to a minimum. The fireproof floor slab finishes 5 ins. from the finished floor. Over this is laid one inch of dry sand, above which is spread a layer of tar paper, and above the paper 2½ ins. of cinder concrete (1:3:6 mix). The top 1½ ins. is a terrazzo wearing surface of cement and Italian marble chips ground and rubbed to a true polished surface. The terrazzo is laid in patterns of various colors determined by the kind of marble used, white and serpentine predominating. These rooms are also provided with marble bases.

The entire area of the inclined concourse is covered with Mason safety treads set in Portland cement. Provision is made for their removal by setting in cast-iron blocks to which the tread is screwed. The team-concourse, comprising almost the entire first floor of the ferry house, is vitrified brick set in asphalt. This paving was adopted after a thorough investigation by the railroad company of granite, wood and asphalt blocks, sheet asphalt, plank and other floors, and was selected because of its great wearing qualities and freedom from slipperiness. The train-concourse floor and some of the storeroom floors are cement. The east-bound waiting-room and the commissary receiving room have asphalt floors of specially selected rock asphalt. The baggage-room has a rock asphalt floor in which is imbedded a cast-iron grill of hexagonal pattern. All asphalt floors are laid under a five-year guarantee. The ferry waiting-room and the piers between the ferry slips are specified of magnesium composition. All office floors are of maple.

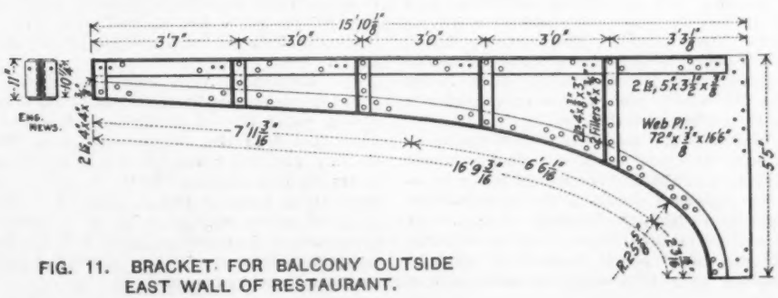


FIG. 11. BRACKET FOR BALCONY OUTSIDE EAST WALL OF RESTAURANT.

ROOFING.—All flat roofs are five-ply tar and gravel, the tar being best straight run American coal-tar pitch. The roofs are guaranteed for ten years by a security company's bond.

DAMP-PROOFING.—To prevent moisture arising from the river and working through the floors, all enclosed rooms of the first floor are protected with a damp-proof course of three-ply felt and coal-tar pitch laid between the fireproof floor slab and the fill. A similar course is provided under the kitchen and toilets of second story and on the inclined plane.

PARTITIONS.—All partitions are constructed of flat metal studding and wire lath. They are of three types: (A) 2-in. solid plaster with one thickness of lath imbedded; (B) 4-in. hollow partition having 2-in. air space, and (C) partitions similar to B but filled solid with cinder concrete. Type B predominates throughout the job. Type C is used where a partition of extra strength is required, as the walls of concourses or where there is a special fire hazard as in the case of store-rooms.

PLASTERING AND FURRING.—All finished rooms are plastered with three coats of patent plaster applied on galvanized metal lath. The furring bars are in all cases bolted to their supports, the only tying allowed being in the attachment of lath. Suspended ceilings are supported on extra strong bolted hangers. In the case of wall furring, bolts are built into the concrete, to which are secured horizontal 1 × ¼-in. bars, 4 ft. c. to c. The ⅞-in. channel furring bars, 12 in. c. to c., are bolted to these bars with angle clips and ¼-in. bolts. In the ferry-concourse, the wall furring is divided into separate panels and the joints covered by pilasters, each cast in one piece

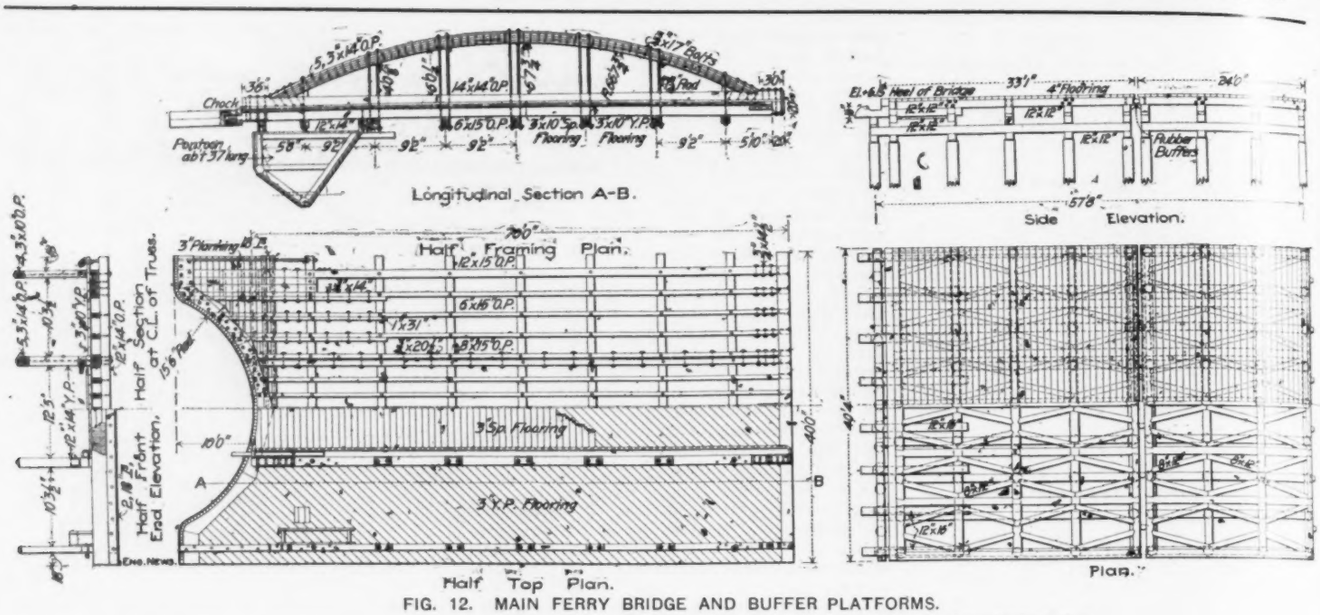


FIG. 12. MAIN FERRY BRIDGE AND BUFFER PLATFORMS.

and applied, for the purpose of reducing the danger of settlement cracks as far as possible.

COPPER WORK.

The ornamental copperwork of the exterior merits special attention. Holes for attaching the copper are left in the concrete by inserting rods through holes bored in the centering laid out accurately by template. The copper is formed in the shop to the architectural designs and reinforced with strap iron riveted to it on the back which is punched to correspond with the holes in the concrete. The sheets are then bolted to the concrete with copper-headed bolts, and all bolt-heads and seams are soldered. The pilasters of the east and west piers are formed out in the concrete to give a solid backing for the copper. Other pilasters, however, and the greater part of the projecting courses and moldings are merely formed in the copper, reinforced with steel angles and straps. Wood planking, supported on steel lookouts, is used under the gutters and cornices, but otherwise no woodwork is used for the support or attachment of copper-work. The copper-work of the tower has already been described above. Wherever copper and galvanized iron are in conjunction they are separated by felt and red-lead to prevent electrolysis. The copper-work is being furnished and erected by Herman & Grace, of Brooklyn.

FIRE PROTECTION.

The structure of the building itself is considered thoroughly fire-resisting, but ample provision was made to guard against damage to the contents and passengers by providing metal-covered doors and hollow metal window frames and sash with wire-glass at all exposed points. This was done on the north and south sides and in the ferry slips, which are the only outside fire exposures, and also in rooms where inflammable material might be stored. The danger of panic was considered as well as the risk of property damage, and consequently all waiting-rooms and passenger concourses were separated from offices or store-rooms by fireproof doors and windows.

The building will be further protected by a system of wet firelines and stand-pipes having 38 2½-in. outlets each provided with a reel and 50 ft. of hose. There are also three permanent turret nozzles on the roof, similar to those in use on fireboats, which are capable of throwing a stream to any point of the roof.

This system is in connection with a system of underground fire-lines which extends throughout the company's yards, and is supplied by an automatic high-pressure pump in the power-house. The main lines within the building are 6-in., with 3-in. branches to the various hose connections. The outlets are so placed that every point in the building may be readily reached with a stream. Two hose connections are also placed on the outside of the building between the ferry slips, and controlled by valves within the building but operated from the outside to prevent freezing. There are three siamese connections on the river-front for fireboats and one on the street for a fire-engine to provide auxiliary pressure in case of necessity. These are dry, and are protected by check valves inside the building. All lines are thoroughly protected from freezing, and the main line on the east side of the ferry-house is run in the warm air duct for this purpose. This duct is described elsewhere. All pipe is extra heavy galvanized wrought iron, and all connections extra heavy malleable iron. The system is designed for a pressure of 300 lbs. per sq. in.

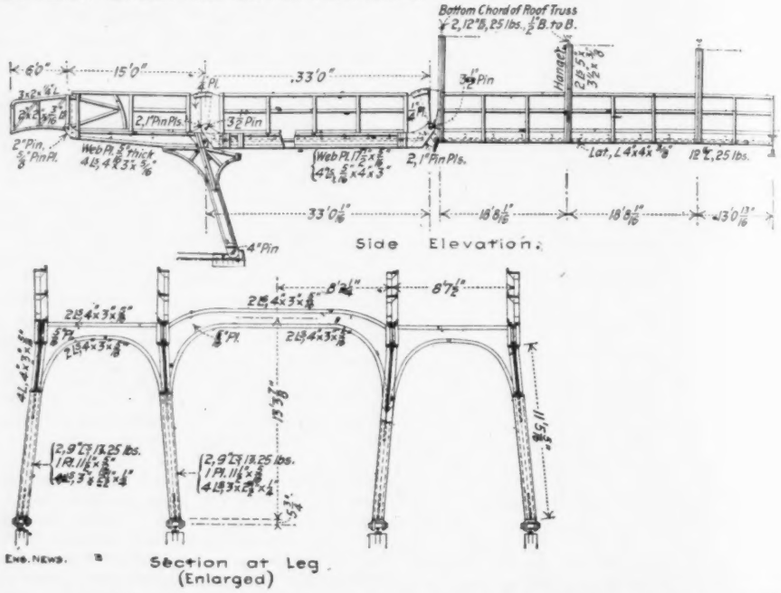


FIG. 13. OVERHEAD LANDING BRIDGE, WITH STERN PATENT SAFETY CANTILEVER SUPPORT.

HEATING AND VENTILATION.

The entire terminal will be heated by a system of hot water (forced circulation), the plant being situated in the power-house, some 600 ft. distant. Hot water was adopted in preference to steam for two reasons: First, on account of the difficulty of running return pipes in connection with the steam apparatus below the first floor on account of the construction; second, the greater satisfaction from the heating standpoint and the economy in maintenance.

In addition to direct heating by radiation distributed throughout the building, there is a supplementary indirect system. The main ferry concourse is heated by an air system under fan pressure, the fan and heating-room occupying one of the piers between the ferry slips. The heat is distributed through large ducts 10 × 9 ft., having outlets the entire length of the concourse, with register openings in each bay. A branch of this large main duct is taken across above the ceiling of the concourse and supplies air to the inside offices on the west side. The fan equipment consists of four 90-in. centrifugal cone pressure-fans, each capable of discharging 3,000,000 cu. ft. of air per hour when running at 200 r. p. m. Each fan is belt-connected to a 15-HP. Sprague alternating-current motor.

In addition to this air supply the outer offices on the west of the ferry house, together with the main waiting-room and its subsidiary rooms, and the restaurant, kitchen and toilets in the railroad station proper, are ventilated by means of exhaust ducts connecting to three 72-in. and one 90-in. vent fans similar in construction to the pressure fans above mentioned. These fans will be driven by direct-connected Sprague direct-current motors of 5 and 15-HP., respectively. They are run in a horizontal position, the shafts being ver-

tical and supported on a special drop forged ball bearing. The heating of the main waiting-room is controlled by means of the Johnson thermostatic automatic regulation.

ELECTRICAL WORK.

High-tension, 2,200-volt, three-phase, 60-cycle alternating current will be generated at the company's power-house (600-ft. distant) and brought to two high-tension switchboards, where it will be reduced to 230 volts by means of single-phase transformers connected three-phase with half voltage taps, six bus-bars being therefore arranged on the switchboards for the lighting, which will supply three-wire circuits having 230 volts between outers. For the motors, the supply is three-phase three-wire. One switchboard will be located under the inclined concourse and will supply all that part of the building referred to as the railroad station, while the other, located in the ferryhouse, will supply that portion. A motor-generator set is also provided in connection with the railroad station switchboard for supplying direct current at 125 volts for the four ventilating exhaust fans and for the elevators. From the two main switchboards current will be distributed by means of 44 panel boards to the various motors and lights throughout the building.

LIGHTING.—The plans provide for about 6,500 incandescent lamps in the terminal. Of these 1,400 are employed in the five large electric signs; one having letters 6 ft. high, surmounting the river elevation of the ferryhouse, and four with 4-ft. letters on the sides of the tower. These signs are backed with steel plates perforated for the lights. Each light is set in a watertight receptacle which is attached to the plate from the back by a special device and furnished with flexible conductors. The lamps can thus be removed from the back, which will effect large saving in the cost of maintenance of the signs.

The four clock-faces in the tower will be illuminated with incandescent lamps and reflectors, the dials being glass.

About 880 lights will be employed in decorative lighting on the exterior; the arches and imposts of the ferry slips on the east elevation, the pediments of the west elevation of the ferryhouse and the cornice of the north elevation of the railroad station being outlined with lights placed in Federal sign receptacles.

The street front of the terminal and the train concourse is illuminaated with twelve-light fixtures placed on the trusses of the marquise and concourse roof from 16 to 33 ft. on centers. The team-concourse on the first floor will be illuminated with 59 arc lamps.

About 3,900 lamps will be employed in interior lighting. Of these, 944 are in the main waiting-room, giving lighting power of 1.68 c. p. per sq. ft. of floor, or .032 c. p. per cu. ft. of space. These are so distributed as to fully illuminate the whole room and also to give ample light for reading on the seats. The ferry concourse on the second floor will have 0.31 c. p. per sq. ft. of floor area and .011 c. p. per cu. ft. of volume. It was not considered necessary to illuminate these concourses as brightly as the waiting-rooms, since they are used merely as passageways between trains, boats and the street.

An emergency gas system is provided for the case of breakdown of the electrical system. A few lights only are placed in each room, the intention being not to fully illuminate the building but merely to provide without delay sufficient light to handle the passenger traffic, and prevent panic and allow necessary business to be carried on.

TELEPHONE AND TELEGRAPH.—Two complete telephone systems will be installed, one for the Commissary Department and one for the Operating Department. These are to be of the intercommunicating type and will connect all the offices and rooms of these respective departments. A complete interior conduit system for public telephone and telegraph is also being installed, so that all of this work can be run concealed.

Each of the more important rooms and the tower will be provided with a clock, there being 28 in all, operated electrically by a master clock system controlled from the U. S. Observatory in Washington. The tower clock has four faces each 12 ft. in diameter.

PLUMBING.

As the building stands over the water there is no main sewer line, but each soil and waste line empties direct into the river with a flap valve at the outlet to protect the traps from cold. Traps below the first floor were avoided on account of the danger of freezing, but in some cases where traps were necessary the steel beams are set a foot below grade and the space filled up with cinder concrete, in which pipes and traps are placed. Throughout the first floor each fixture discharges individually into the river, and siphonage of traps is prevented by mercury vents, no other venting being necessary. On the second floor each group of fixtures has its own soil and waste lines and stack, and the traps are vented in the usual manner. Except as modified by local conditions as described above, all plumbing work is installed as required by the rules and regulations of the Bureau of Buildings of the City of New York.

The following is the list of principal plumbing fixtures to be installed in the entire terminal:

Water closets	69
Lavatories	68
Urinals	37
Slop sinks	12
Bath tubs	3
Shower baths	5

All lavatories, slop sinks and kitchen sinks are provided with hot water, two Tobey water-heaters being provided for that purpose.

A very copious fresh water supply is provided, since all the ferryboats take water for their boilers while in the slips. The water mains in the ferryhouse are 6-in. and 4-in., and two tanks of 1,200 and 4,000 gals. capacity are provided in the attic space to insure uniform pressure and the quick delivery of a large quantity of water to the boats. Hose bibs are placed at frequent intervals throughout the team and train-concourses for cleaning purposes. The water system for the supply of boats and fixtures is entirely separate from the fire system described above, and is connected with the city mains.

FERRY LANDING BRIDGES.

The main ferry bridges, on the first floor, to which the ferryboat is made fast, are constructed of wood in the usual manner (see Fig. 12). The forward end of each bridge is supported by a pontoon, and is further suspended from the second (transverse) roof-truss of the slip by chains passing around overhead sheaves and operated by windlass on the bridge deck. At the rear end the bridge is hinged to the forward end of a double buffer-platform supported on piles, driven close together. The impact of the ferryboat is taken up by the inertia of these platforms and the resistance of the piles; the platforms are separated from the floor of the building proper by a 6-in. air space covered with a sliding plate.

From the balconies opening from the ferry-concourse passengers pass over bridges to the upper deck of boats. These bridges are for part of their length rigidly hung from the trusses above, but the outer sections are supported from the pontoon bridge below and rise and fall with it [the mean fall of tide between high and low water is 5 ft.]. The supporting device is the invention of the consulting engineer of the work, Mr. E. W. Stern, who has applied for patents. The outer end of the overhead bridge is 24 ft. beyond the point of support on the pontoon bridge, while the length of the suspended span is much less than the length of the pontoon bridges. This necessitates some sort of compensating device to make the rise and fall of the outer ends of the two bridges the same. The movable portion of the upper bridge is in three sections, as will be seen by reference to Fig. 13. The inner section is a simple girder span pin connected at each end. The middle section is a cantilever construction supported on posts, pin-connected at the bottom to a shoe on the pontoon bridge, and at the top to the girder span, which thus acts as a link to hold the cantilever up. The outer section is a so-called apron bridge, pivoted, and balanced to work by hand, and operated by the deck-hand on the boat. Its purpose is that of an ordinary gang-plank. It will be noted that in the operation of this structure the floor of the cantilever span remains practically horizontal and the pin of the apron bridge moves vertically the same height as the pin at the bottom of the post.

It will be noticed that there is a heavy bracket on the back of the post under the girder span, but in no way connected to it, and that the shoe at the bottom of the post is arranged to slide on a track. The object of this is to furnish a safeguard in case of accident due to the boat getting out of control and ramming the pontoon bridge with sufficient force to unseat it from its bearings [this has happened] and drive the bridge back on the ferryhouse floor for a considerable distance. Such an accident would result in a serious disaster if the pin at the foot of the post were immovable, since the upper bridge would crash down on the deck of the ferryboat. With the present device, however, the bracket would engage the girder span and the cantilever span be held up while the shoe slides along the track.

TRAIN SHED.

The train shed was designed by the Chief Engineer of the railway company, and is believed to be of an entirely new type. The defects inherent in the wide-span train shed and its great initial and maintenance cost are well known, and after considering several designs of steel arches of various span and types, it was decided to abandon the wide arch entirely and employ some form of open umbrella shed. As it was the intention to place the tracks in pairs to reduce the number of platforms, an umbrella shed of the usual type would necessitate a wide opening between the sheds, and to avoid this undesirable feature the present shed was designed. The essential features, Fig. 14, are a low roof of glass and concrete supported on steel trusses and a narrow continuous opening with aprons at the side extending as low as the smokestack of an engine, so that all smoke passes directly out of the shed to the outer air. The details of the construction are shown in Fig. 15. Cast-iron columns placed on the center line of each platform support transverse-arched plate girders. The top section of the column above the neck is cast square and the girders are bolted to the columns with through bolts. The bents are 27 ft., c. to c., and the total length of the shed, including the overhang at each end, is 607 ft. Expansion is taken care of by an expansion joint placed at every other column, that is, every 54 ft. Transversely, there are eight spans of arches, and the columns are 43 ft. 4½ ins. on centers, except the end spans which cover only one track, and are, respectively, 30 ft. 4½ ins. and 35 ft. 10½ ins. between centers of columns.

The smoke opening over each track is formed by a pair of light lattice stringers which are wrapped with expanded metal and cased solidly in concrete, the surface being floated smooth. The portion of each main girder where it crosses the opening is also encased in concrete, so that the smoke and gases come in contact with no steel-work. The aprons formed by the casing of the stringer at the side of the smoke opening extend low enough to catch all the smoke from the stacks. They also are carried a short distance above the roof as parapets and form an effectual protection to the platforms from driving rain. Narrow openings are pierced in the aprons every few feet, just under the roof, to allow the escape of any smoke or gas that may find its way under the shed. A continuous ventilator is placed on the central skylight at the highest level of the roof for a similar purpose.

Connecting each two columns longitudinally is a steel member, built up of two channels and a plate in the form of a trough which serves both as a stringer to support the roof and as a rain water conductor. The water passes off through leaders enclosed in the columns and thence into drains under the platforms. The trough is lined with copper. The shed is braced longitudinally by plate-and-angle braces riveted to the steel trough mentioned above and bolted to the columns in similar manner to the main girders. The braces are built with a curved flange to correspond with the lower chord of the main (transverse) girders, and the four members springing away from the

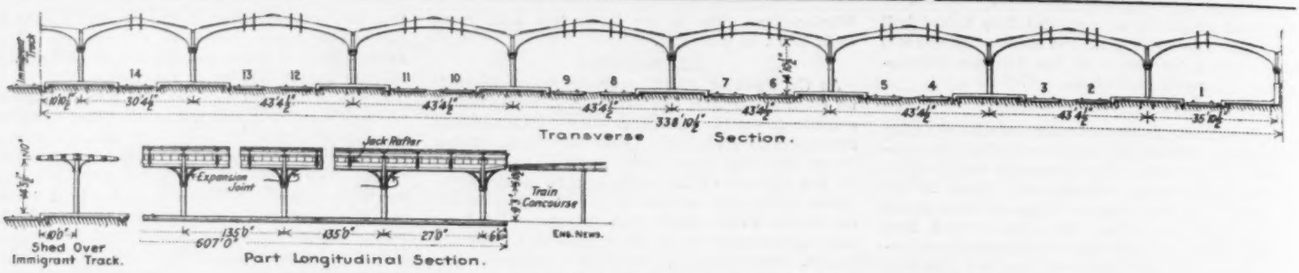


FIG. 14. CROSS-SECTION AND PART LONGITUDINAL SECTION OF TRAIN-SHED.

columns give a very pleasing effect. The columns are fluted and have cast-iron caps under the spring of the arches.

There is a narrow strip of concrete and expanded-metal roof on each side of the gutter, and a similar strip adjacent to the smoke opening. All the rest of the roof is covered with skylight construction supported on deck beams and bulb angles. The skylights are of the "Anti-Pluvius" type.

This shed is now practically completed and portions of it have been completed and in use for several months. As far as can be judged from this limited time, it fully meets the requirements and is giving complete satisfaction.

At its east end the train shed abuts against the glass canopy over the train concourse, a wide platform along the west wall of the train waiting-room. The canopy, whose peculiar supporting trusses are shown in Fig. 16, is part of the terminal station work. The joint between it and the train shed, about 12 ins. wide, is made by a copper gutter, integral with the copper facing of the east gable of the train shed.

The train platforms are reinforced concrete slabs 6 ins. thick and 20 ft. wide, supported on

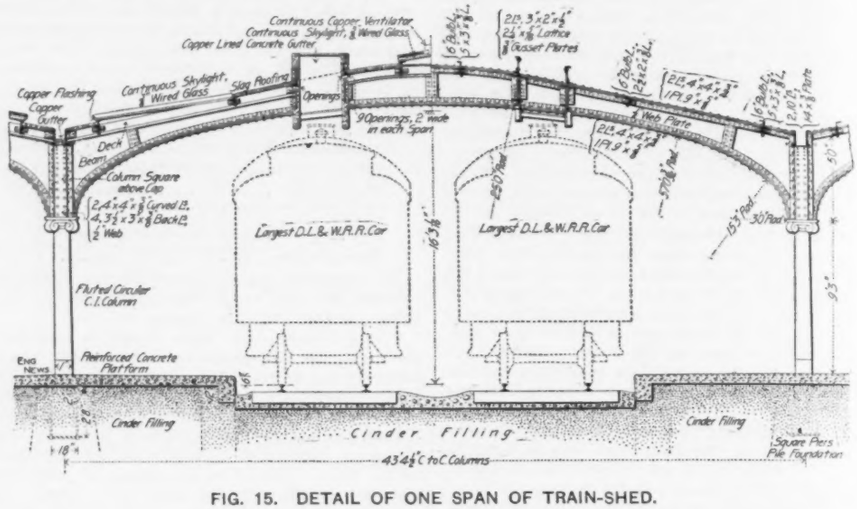


FIG. 15. DETAIL OF ONE SPAN OF TRAIN-SHED.

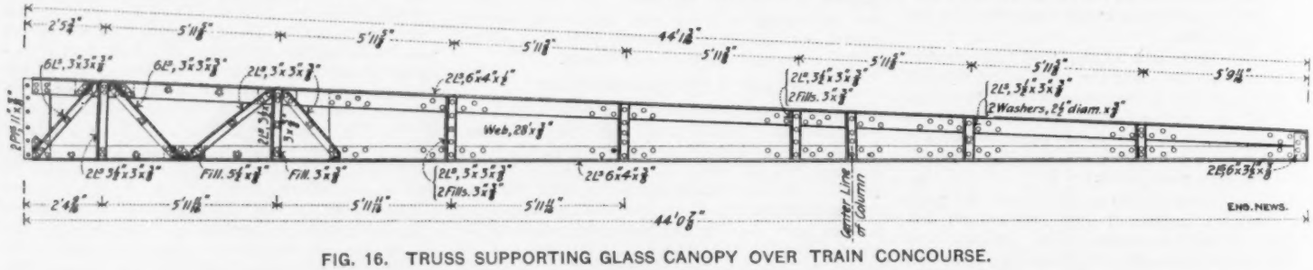


FIG. 16. TRUSS SUPPORTING GLASS CANOPY OVER TRAIN CONCOURSE.

longitudinal reinforced concrete beams at the sides and center. The side beams also form the side of the track pit. The concrete beams are supported on concrete piers 7 ft., c. to c., built on wooden piles which are driven with their tops below the level of the ground water. This construction was adopted on account of the poor character of the ground, which is mainly a cinder fill. The piers carrying the train-shed columns are supported by four piles each. Intermediate piers in the central row and all those for side girders are built over a single pile and were made in the following manner: After the pile had been driven down as far as possible, the head was cut off smooth and an oak follower enclosed loosely in a box or sheath of 2-in. pine plank placed upon it; this follower and sheath is shown in Fig. 17. The sheath was beveled and covered with galvanized iron at its lower end. The follower was somewhat longer than the sheath, and was provided with 2-in. shoulders at its upper end; it was of sufficient length to drive the pile below water level, and the sheath was forced down with it by the shoulders on the follower. When the top of the sheath reached the desired level for the top of the pier, the follower was withdrawn, leaving the sheath permanently in the ground as a form for the concrete. In building the platform slab, the ground was leveled off and the concrete placed directly upon it, but the slab was reinforced to take the entire load without reference to the support afforded by the ground under it. The platforms are finished with cement wearing surface.

A portion of the yards and train-shed extends beyond the bulkhead wall (see Fig. 2), which forms the limit of solid ground. As it was inadvisable to change the bulkhead, piles were driven over the area in question about 3 ft. on centers and cut off at low water level. A solid timber platform was built on these piles and cinders filled in above it up to grade. A concrete retaining wall was built on the platform at its outer edge to retain the fill. Where the train-shed extended over this construction the concrete piers were carried down to the platform. It will be noted that no piles or woodwork are above water level.

Some numerical data, not given in the preceding, which may be of interest in connection with this terminal station, are the following:

Terminal building,	total ground area	138,800 sq. ft.
Main waiting-room,	area	8,840 " "
	seating capacity	140
Combined areas of ferry waiting-rooms		11,400 " "
	seating capacity	195
Ferry concourse	area	28,900 " "
	seats	72
West-bound concourse,	area	5,400 " "
Inclined concourse,	"	2,600 " "
Team concourse,	"	42,000 " "
Train concourse,	"	21,800 " "
Total area of concourses and waiting-rooms		121,000 sq. ft.

The main terminal building is being erected by Snare & Triest, who are general contractors for the entire work. The steelwork was furnished by the Fort Pitt Bridge Works, of Pittsburg, Pa., but is being erected by the general contractors. Besides the general contract, the following

Fig. 17. Pile Follower and Concrete Mold, for Piles of Station Platforms.

special contracts for work on the station may be noted: heating and ventilating, Baldwin Engineering Co.; electrical work, Peet, McAnerney & Powers; plumbing, Gus Staats; clocks, Selfwinding Clock Co.; refrigerating equipment, Brunswick Refrigerating Co.; all of New York, N. Y.

As already noted, the train-shed and the foundations of the railroad and ferry station were designed by the engineering department of the Delaware, Lackawanna & Western R. R. Co., Mr. Lincoln Bush, M. Am. Soc. C. E., Chief Engineer, and erected under the supervision of Mr. Joseph Snell, Superintendent of Docks & Buildings. The plan and architectural design of the railroad station and ferryhouse is the work of Mr. Kenneth M. Murchison, of New York, N. Y., under whose supervision the work was carried out in all its details. Mr. E. W. Stern, of New York, Jr., signed the steelwork as Consulting Engineer.

THE PASSING OF CABLE RAILWAYS IN THE UNITED STATES.

The abandonment of cable traction by the street railways of Chicago, and the conversion of the cable lines to the electric railway trolley system which is now taking place, marks one of the closing events in the history of cable traction, and it is to be noted that this step would have been taken long ago but for contentions between the city and the railway companies, as noted in another column. This abandonment of the cable system in Chicago has led us to make some inquiries as to the history of the system in that and other cities, and the information procured is presented below.

Cable traction for street railways was originally intended for steep-grade lines, and was first introduced on Clay St., San Francisco, in 1873. This line had grades of 16.6%. It was built by Mr. Andrew Hallidie, whose name is closely associated with the early development of cable traction. San Francisco had nearly 100 miles of cable lines, with grades as steep as 19%. Some of the lines, however, are already being converted to electric traction.

The first adaptation of the cable system to lines on level ground and in a district subject to snow was in Chicago. The Chicago City Ry. commenced work in August 1881, and operated the first cable train in that city in January, 1882; this train consisted of 10 cars hauled by a single grip car. In 1905, the company (operating on the south side) had 34.75 miles of cable line, but 15 miles were converted to the electric trolley system on July 22, 1906, and preparations are now being made to extend the trolley system over the remainder of the cable lines. The maximum grades operated are 2% on the cable lines and 7% on the electric lines, while the speeds are 10 and 12 miles an hour on the cable and electric lines respectively. The use of the cable on the north and west side lines of companies now merged in the Chicago Union Traction Co. was commenced in 1886. The greatest mileage operated was 47.56 miles, and this has now been reduced considerably, while all the lines are now being converted to the electric trolley system. The lines are practically level, except at the three tunnels under the river.

The Cincinnati Street Ry. began the construction of cable lines in 1884-5, and in 1896 had about 25 miles in operation. After that, cable traction was gradually abandoned in favor of electric traction, and the last cable line was converted in 1901. The maximum grades were 13% on the cable lines, and 10½% on the electric lines; the speeds were 8 and 10 miles an hour for the former, while the latter are run on a schedule of 10 miles an hour.

At Kansas City, Mo., the Metropolitan Street Ry. Co. constructed its first cable system in 1885, and in 1898 it had 70 miles of single track. At present there are only four miles of single track, and the last line will be abandoned in a year or two. The maximum grade on the original cable lines was 18%, and on the existing lines it is 12%, while the electric lines have a maximum grade of 10%. The cables ran at a speed of nine miles an hour, and the average speed of the cars (including stops) was about 6½ miles an hour. The average speed on the electric lines (including stops) is about nine miles an hour.

At New York, the first cable line was the 125th St. crosstown line, in 1884. This was followed by a rapid development on the main north and south lines and from 1895 to 1899 there were 51.14 miles of single track. They soon began to be converted to the electric system, and the last cable line was abandoned in 1901. With both cable and electric traction the maximum grade was 13% and the schedules were based on a maximum speed of 12 miles an hour.

At Philadelphia, Pa., the first cable line was opened in April, 1883, and the greatest mileage was 20½ miles of single line. The last cable line was abandoned in June, 1895. The maximum grades on the cable lines were 10%, while those on the electric lines are 8%. The speeds of the cables were 6¾ miles and 9 miles an hour, respectively, east and west of 20th St., while on the electric lines the general average is 8.15 miles an hour.

At Washington, D. C., both the Washington Ry. & Electric Co. and the Capital Traction Co. have introduced and abandoned cable traction. The latter road built its first cable line in 1889, and had a maximum of 22 miles in operation in 1896 and 1897, but the last line was abandoned in 1898. The maximum grades were 6% on both the old cable and present electric lines, while the speeds were 10 and 12 miles an hour for the cables as compared with 12 and 15 miles an hour for the electric lines.

At Seattle, Wash., the Seattle Electric Co. built its first cable line in 1888; the maximum mileage operated was 22 miles in 1899. There are now only 13½ miles, but the company has no idea of abandoning any of its present cable lines in the near future. The maximum grade on the cable lines is 21%. On the electric lines it is 16% for one block (256 ft.); this is without counterweight, but the maximum grade where a counterweight system is used is 18.6%. The speed on the cable lines is 9 miles an hour. The franchise reads: "The rate of speed at which cars may be run within the business and settled residential sections of the city, shall not exceed 12 miles per hour and shall be subject to regulation and control by City Council by Ordinance;" this is exceeded, however, in the rural districts, where speeds of 25 miles an hour are attained.

THE WALSCHAERT VALVE GEAR.*

While the Walschaert valve gear is an old invention, it is only within the past few years that it has been used to any great extent in this country. The inventor, Mr. Egide Walschaert, was borne Jan. 21, 1820, at Malines, Belgium, and died Feb. 18, 1901, at Saint Gilles, near Brussels, at the age of 81 years.

In 1844 he invented the valve motion that now bears his name. His invention has been used very extensively in Europe for a number of years, and on account of the increase in size of motive power in America, master mechanics began to realize the importance of changing the valve motion, which resulted in the American locomotive builders bringing the Walschaert valve gear into use. The advantages of this valve gear is the difference in weight over the Stephenson link motion. According to statements made by the American Locomotive Works, a saving of 1,745 lbs. is possible on our large engines. It can readily be seen that this would reduce the wear on all valve connections; also the liability of break-downs is reduced to a great extent.

The Walschaert valve motion is direct and gives a constant lead from all points of the cut-off, while with the Stephenson link motion the lead increases as the cut-off is shortened. The constant lead is an advantage, as in the case of the link motion it is a difficult matter to obtain sufficient lead with large cylinders in the longer points of the cut-off and at the same time keep down the lead and subsequent pre-admission and excess compression in the shorter points of the cut-off, where most of the high-speed work is performed. The advantage of constant lead on engines with large cylinders is manifest because of the possibility of giving an amount of lead in a long cut-off to properly cushion the reciprocating parts and at the same time reduce the pre-admission and compression at short cut-off, thus making a more free working and an easier running engine, saving steam and reducing pounding of the bearings, which is very noticeable in our heavy engines, carrying a high steam pressure.

From the point of inspection this motion is far superior to any valve motion in use at the present date. All parts liable to defects are out in plain view of both engineer and inspector, or, in fact, any one who is interested in the condition of the locomotive. All parts are easily examined from the outside, it only being necessary to get under the engine in case of packing a cellar.

Owing to the fact that engines equipped with this valve motion have been in service in this country only a very short time, it is a difficult matter to get very many different expressions from others. On this account it will be necessary for me to give the information obtained from my own personal observation.

In regard to the difference in the cost of maintenance of the Walschaert valve gear over the Stephenson link motion, I believe the cost to be fully 25% less. The above figures were obtained from the Chicago, Rock Island & Pacific roundhouse at Burr Oak, Ill., where we have a number of engines equipped with the Walschaert valve gear, while others are equipped with the Stephenson link motion, both classes being in freight service out of that point.

Engine failures due to the breaking of valve motion connections during twelve months' service have been very slight. With 15 engines equipped with the Walschaert valve gear we have had only three failures that were chargeable to valve motion failing, while with engines equipped with the Stephenson link motion we have had at least three times as many failures due to the link motion getting out of order.

In view of the fact that the Walschaert link, not being influenced by a backing up eccentric, does not rock through as large an angle as the ordinary Stephenson link, the link has a more favorable action on the link block with the Walschaert gear and does not have a tendency to spring the motion as much as the Stephenson link when at and near the extremity of its stroke. It should also be noticed that with the Walschaert gear all parts in connection with the valve move in almost a straight line, which does away with the up-and-down motion that is very noticeable with the Stephenson link. There is no question in my mind but what this up-and-down motion has a tendency to cause a rocking action of the valve upon its seat, whereas with the Walschaert link the valve has an easy gliding motion and is not so apt to hollow the valve seat.

With reference to engines equipped with this gear handling tonnage as compared with those equipped with the Stephenson motion, my experience has been that where tonnage is considered the main factor and speed as a secondary consideration, the Walschaert motion, in my opinion, has the advantage over the Stephenson motion, as it will handle a train better at a slow rate of speed with very little slipping, while with the Stephenson motion at a slow rate of speed the engine requires greater care in handling in order to prevent this trouble, making it necessary to use a greater amount of sand.

In regard to speed, I am not in a position to say which motion has the advantage, as none of our engines in passenger service are equipped with the Walschaert valve gear. In freight service we have about the same number of each, and they take their turn in all classes of freight, both fast and slow. It seems to be the general opinion of the men running these engines that engines equipped with the Stephenson motion can take a train of the same tonnage and make better time on the level or where the grade is in their favor than they can with those equipped with the Walschaert motion, but when they get on the hills or where the grade is against them they can make better time with the Walschaert than they can with the Stephenson motion. The only reason I can advance for this difference is the manner in which the valves are set, as both engines are of the same size and weight and carry the same steam pressure, which is 185 lbs.

The valves on our engines equipped with the Stephenson link motion are set with $^1/_{32}$-in. lead at full stroke, making about ¼-in. lead in the 6-in. cut-off; valve lap, 1 in.

Valves on our engines equipped with the Walschaert valve gear are set as follows: Five of them have ¼-in. lead, which is constant, and $^7/_8$-in. lap; the remaining number have $^3/_{16}$-in. lead and $^{15}/_{16}$-in. lap, and these give the best results. The engines referred to were built for freight service and were not intended for high speed.

*Report by O. H. Rehmeyer, submitted at the annual meeting of the Traveling Engineers' Association, Chicago, August, 1906.

IRON ORE PRODUCTION IN THE UNITED STATES in 1905 aggregated 45,526,133 long tons. This was 54% in excess of the production of 1904 and 20% in excess of the previous maximum output, which latter occurred in 1902. In a report on this subject for the forthcoming volume of "Mineral Resources of the United States," Mr. John Birkinbine asserts that the iron ore production in this country for 1905 was more than double that of the combined production of the German Empire and the United Kingdom for the same year. The leading part played by the Lake Superior region in the production of iron ore is stated by Mr. Birkinbine in his report as follows:

The Lake Superior region, which includes five mineral ranges in states bordering upon the great inland sea, continues, by augmented annual outputs, to outrank all other known deposits in supplying iron ores. In the year 1905 its production of 33,325,018 long tons exceeded its former maximum of 26,977,404 long tons in 1902 by 24%, and the record of 1904 by 65%.

The mines which compose the five ranges of the Lake Superior region contributed more than three-fourths of the total iron ore mined in the United States in 1905, and to date this region has supplied an aggregate of over 300,000,000 long tons of iron ore. Of this quantity the Marquette Range in Michigan, which has been producing since 1854, has shipped 77,000,000 long tons; the Menominee Range, in Michigan and Wisconsin, has, since its opening in 1877, furnished 53,500,000 long tons; the Gogebic Range, in Michigan and Wisconsin, opened in 1884, has shipped 47,000,000 long tons; the Vermilion Range in Minnesota, opened also in 1884, has supplied 23,500,000 long tons; but the phenomenal shipments have been from the Mesabi Range in Minnesota, which since 1892 have reached a total of 99,000,000 long tons, or nearly one-third of the ore obtained from the Lake Superior region.

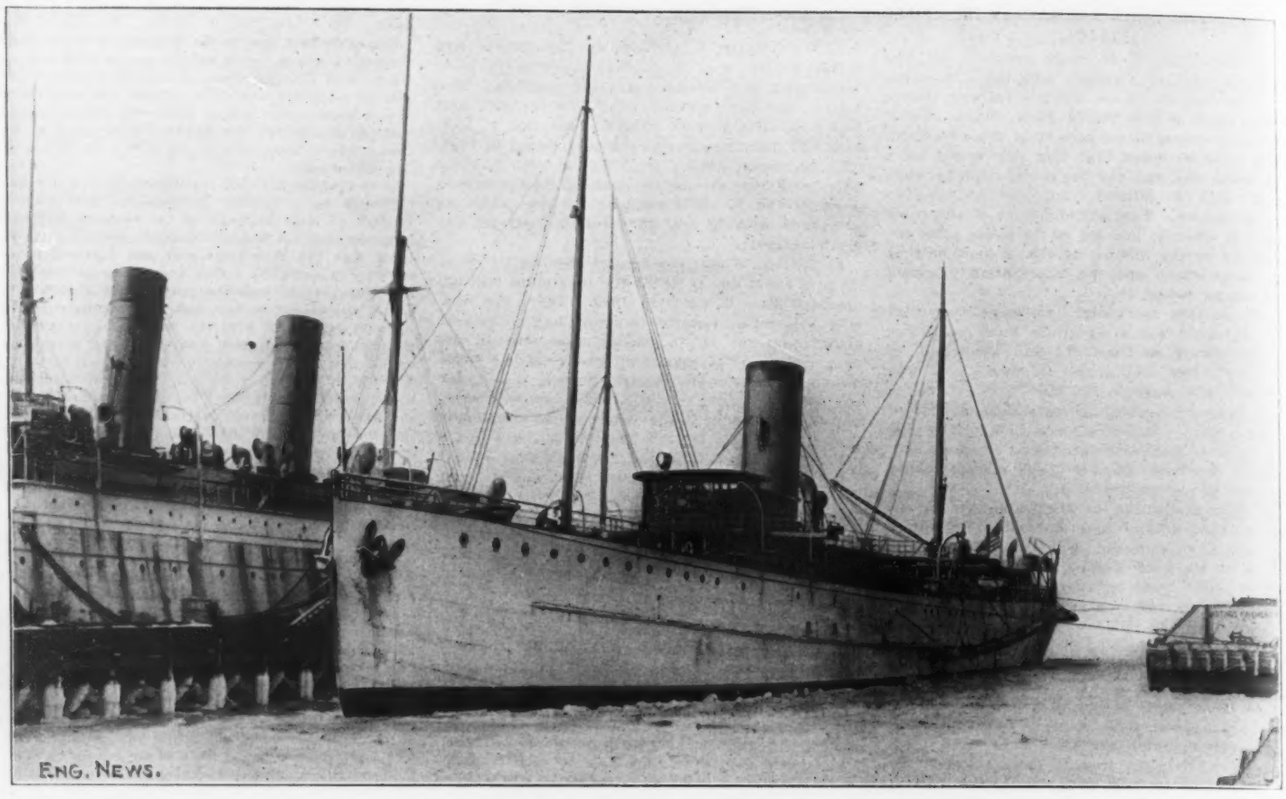


FIG. 1. U. S. DREDGE MANHATTAN ICE BOUND AT DOCK, FEBRUARY, 1905.

EXPERIENCE WITH THE U. S. DREDGES "MANHATTAN" AND "ATLANTIC," EMPLOYED UPON AMBROSE CHANNEL, NEW YORK HARBOR.*

By Henry N. Babcock,† M. Am. Soc. C. E.

The contract for improving Ambrose Channel, entered into May 12, 1899, provided for the excavation of the entire channel, an estimated amount of 42,500,000 cu. yds. of excavation, at a rate sufficient to secure its completion in 1905, with a provision that no payment should be due if the required rate was not maintained. As early as 1902, it became apparent to the contractor that he could not maintain such a rate of excavation, and since withholding payments would leave him unable to work at all, and thus would suspend the improvement, a supplementary agreement was made, modifying the rate required as a condition of payment, and stipulating that the United States should itself have the right to further the progress by putting on other dredges whenever they could be obtained.

In 1903 Congress provided funds for building Government dredges, appropriating a sum largely in excess of any estimates of the amount needed for work under the contract. Construction of two dredges was begun under contract between Major J. C. Sanford, Corps of Engineers, to whom had been assigned the duty of designing and constructing two dredges for this work, and the Maryland Steel Co., of Sparrows Point, Md.

When construction was completed the dredges were sent to New York Harbor, the "Manhattan" arriving October 31, 1904, and the "Atlantic," April 1, 1905. After certain trials before acceptance, the "Manhattan" was turned over to you Feb. 8, 1905, and the "Atlantic," June 10, 1905. Since these dates the two dredges have been at work in Ambrose Channel, in cuts parallel to and under the same conditions as the contractor's dredges. The object of this paper is to place on record the results of one year's experience with and observation of these dredges, so that they may be accessible to interested persons. It is perhaps likely that in Ambrose Channel the importance and amount of work, the exposed situation, the depth required (40 ft.), the kind of material, and the fact that we are working alongside of a contractor, may have developed important additions or alterations more rapidly than would have been done elsewhere.

GENERAL DESCRIPTION OF THE DREDGES.

The dredges "Manhattan" and "Atlantic" were built from the same plans; they are steel, twin-screw steamers, 288 ft. long, 48 ft. wide, having within their hulls two nearly equal sand-bins, one forward and one aft, both bins together carrying when fully loaded about 2,300 cu. yds. of material. [See Fig. 1.]

Each dredge is provided with two 20-in. centrifugal pumps (Bucyrus Co., South Milwaukee), pumping material through 20-in. steel suction pipes, one on each side of the ship. The pumps are placed nearly amidships, with centers about 4 ft. above the light draft line; the suction pipes, 97 ft. long (at first), connected with the pump through a 90° elbow, and trailed aft, the drag or mouthpiece dragging over the bottom and the dredge pumping while under way at slow speed. The discharge pipes rise vertically from the pumps about 2½ ft. to a Y, the branches turning to the forward and after bins. The amount discharged into each bin is controlled by a flap valve in the Y. The total rise from the pump to the discharge is 11 ft. When loaded the dredge goes to sea and dumps in deep water through 16 gates, 8 in the bottom of each bin. The surplus water during dredging escapes through overflows near the tops of the bins.

Steam is supplied by four Scotch boilers, 14 ft. in diameter and 12 ft. long.

CHARACTER OF MATERIAL.

East Channel, as Ambrose Channel was called before improvement, was a natural channel across the outer bar of New York Harbor, about 7 miles long between the 40-ft. curves; half way through the bar from the inside it had fair depths of 25 to 30 ft., the outer half spreading out into a broad fan with 15 to 22 ft. depth. The material of the bottom in the outer part was coarse sand or fine gravel, with a little clay here and there and some shells in places; in the inner part it was finer sand, occasionally with a small amount of clay, and often covered with 2 to 10 ft. of mud. East Channel was not infrequently used as a dumping ground for refuse some years ago, when the contents of dredging or refuse scows was dumped out of sight anywhere, at the discretion of tug-boat men. Nearly every description of thing which could pass through the pipes has been pumped up: bricks, paving blocks, pieces of flagging, timber, wire rope, railroad iron, bones, leather, scrap tin, etc. Two modern projectiles, one 5-in. and one 3-in. shell, and a 20-ft. length of 1½-in. chain, are among the articles recovered. It is not easy to see how such things can pass through the pump; they do not always pass through without damaging it. It is not to be understood that this refuse forms a large percentage of the total dredged; on an average sand and mud constitute probably 97% of the total, the miscellaneous refuse averaging about 3%.

The coarse sand on the outer part of the bar is by far the easiest material to excavate with suction dredges, but the Government dredges find no difficulty with the finer and more compact sand farther in. Nor is any trouble expected in handling the mud in the inner part of the channel, except the usual one that it will not settle readily in the bins and that much of it will pass out with the overflow.

MANNER OF WORKING.

The dredges work by lowering the drags to the bottom and pumping while under way at a slow speed, not exceeding 1½ miles per hour when going against the current; with the current the speed necessarily runs up to three or sometimes to four miles. The drags are each 5 ft. wide and are about 52 ft. apart, and the work results in cutting out two furrows of 5 ft. width along the ship's course. A dredge will ordinarily take in a load of 2,200 cu. yds.—approximately 1,800 yds. in place—in a course 15,000 to 20,000 ft. long, which would make the average depth of the furrow 3 to 4 ins.

The courses are laid out of such a length that, as nearly as can be estimated, the dredge may get a full load in going up and back once. This makes a shorter trip to the dump, and saves the time of an unnecessary number of turns.

When the loading is completed the dredge goes to sea, a distance at present of about eight miles, and dumps the material. The average time going to the dump is 46 minutes, and returning, 36 minutes; a total of 82 minutes (or 28% of the total working time) per load averaging 2,044 cu. yds. There is no known contrivance to obviate the necessity of the dredge carrying its own load to sea. Some years ago the experiment of pumping into scows was tried and abandoned, because in this exposed location there were few days when a dredge and scow could lie alongside or near together.

Since August, 1905, the dredges have been working continuously day and night, except when delayed by weather and repairs, and excepting Sundays and holidays. It was intended that they should begin this as soon as the crew became familiar with the channel, but at first the pipes and pumps broke so frequently that it was difficult to keep going by daylight only. Afterwards some of the officers of the dredges who had had experience elsewhere were positive that night work could not be done economically, and that we were certainly not ready for it. So it became necessary to make a beginning, ready or not, and once begun it has never been given up. The efficiency of night work is fully 90% of that of day work for an equal number of hours.

The dredges now start out at 5 o'clock Monday morning and, except for breakdowns, do not return to the

*A report to Col. W. L. Marshall, Corps of Engineers, U. S. A., New York City; report dated June 30, 1906.

†U. S. Assistant Engineer on New York Harbor Improvements.

dock until Saturday noon. Saturday afternoon and part of the night or of Sunday are spent in coaling, taking on supplies, cleaning boilers, etc. Taking into account this and the lost time due to repairs and weather, the best average time per day made for any one month was 19¼ hours. The average since beginning night work has been 18½ hours; prior to that it was slightly under 7 hours. For day and night work both a complement of 54 men to each dredge is required.

DATA CONCERNING WORK DONE.

Before July 1, 1905, the dredges were undergoing considerable alterations and repairs to better adapt them to dredging the channel material. They had removed 467,-470 cu. yds. of material in eight months' work of one dredge, and two months' of the other (total ten months) at a field cost of 9.9 cts. per yd., as nearly as data at hand show; some of the earlier bills were not paid from this office.

From July 1, 1905, to May 31, 1906, eleven months' work for each dredge, they took out 3,258,707 cu. yds., at a field cost of 5.274 cts. per yd., the results from the two dredges being almost identical. This cost is divided up, in reference to different parts of the work done, as follows:

Pumping	3.357 cts.	=	63.66%
Turning	0.206 cts.	=	3.90%
Going to dump	0.835 cts.	=	15.83%
Dumping	0.223 cts.	=	4.23%
Returning from dump	0.653 cts.	=	12.39%
	5.274 cts.	=	100%

The getting of the material, pumping and turning, make almost exactly two-thirds the cost, and getting rid of it, the other one-third.

Divided up according to different items of expenditure, it is:

Pay-roll	1.761 cts.	=	33.39%
Coal	1.408 cts.	=	26.69%
Water	0.039 cts.	=	00.75%
Subsistence	0.476 cts.	=	9.02%
Engine-room supplies	0.098 cts.	=	1.87%
Miscellaneous supplies	0.150 cts.	=	2.84%
Repairs and renewals	1.342 cts.	=	25.44%
	5.274 cts.	=	100%

These dredges are able sea-boats and stay at work in Ambrose Channel in stormy weather, until it gets too rough to go to sea and dump, turning in the trough of the waves. They cannot work quite as fast in rough as in still weather, because the pipes have to be lifted more frequently to prevent the ship riding over them. When the weather gets too thick to see buoys and ranges work has to be suspended. But the chief cause of delays has been due to repairing.

The following table gives the relative importance of the different causes of delay and lost time, being the record of two dredges working eleven months each, July 1, 1905, to May 31, 1906:

	Whole days.	Parts of days. hrs. mins.	Total in days of 24 hrs.	Per-centage.
Actually at work		8,041 — 38	335.1	50.0
Repairing	112	628 — 05	138.1	20.6
Fog and snow		272 — 40	11.5	1.7
Storm	6	177 — 15	13.4	2.0
Taking on coal, etc., minor repairs and clearing up: parts of Saturdays and Mondays		1,102 — 37	46.0	6.9
Miscellaneous		89 — 35	3.7	0.6
In July, 1905, before night work began		294 — 00	12.2	1.8
Sundays&holidays.	110	... — ..	110.0	16.4
			670.0	100

The lost time due to repairs is the item which we are trying to reduce now. The value of this time far exceeds the cash cost of the repairs. During the last three months (March to May 31, 1906) each dredge has averaged 8,908 cu. yds. of excavation per day for every day on which it has worked at all; at 9 cts. per yd., the price paid for contract work in the same channel, this amounts to $801 per day, and at this per diem valuation the value of time lost by reason of repairs in eleven months as above is $110,538, while the money actually paid for these repairs was $43,721.

The kind of repairs which have been most urgent has varied; at first, the chief difficulty was with the suction pipes; later, it was with the pumps and drags. These have been remedied, partly as regards cost, and wholly as far as any considerable delays are concerned. The imperative work now is the care of the outboard shaft bearings. It is too soon to say whether or not the last improvement in them will prove quite satisfactory.

ALTERATIONS AND REPAIRS.

The alterations which have been made in the dredges, some of them necessary on account of local conditions of Ambrose Channel, have, it is thought, enough of general application to justify a detailed description of them.

SUCTION PIPES.—These pipes, one on each side of the dredge, consisted of : (1) an elbow; (2) two rubber suction hose, each piece 4½ ft. long over all, separated by a 12-in. steel distance-piece; (3) four wrought iron pipes, 20 ft. long, ¼-in. thick; (4) a drag, 5½ ft. long; making a total length of 98 ft. The pipe was raised and lowered by two bridle-chains with wire rope hoisting cables, the forward bridle being attached at each end of the rubber hose, and the after one at the drag and at a point on the after length of pipe, 4½ ft. from its forward flange, leaving 64½ ft. of 20-in. pipe unsupported.

The pipes were bolted together with 16 1¼-in. bolts, through flanges of forged steel riveted to the pipe ends. The flanges were ⅞-in. thick, and were riveted to the pipe with two rows of staggered rivets, ¾-in. diameter and countersunk both sides; the rows were 1 in. apart center to center, and the rivets at 4-in. intervals in each row.

These pipes gave trouble from the start. Considered as a beam unsupported for 64½ ft., the whole pipe was weak. The weakest part was at the riveting to the flange, and at that line the pipes frequently tore in two. They were repaired and strengthened with angle irons at considerable expense, in order to keep the dredge at work, and a truss was made for temporary service, until new pipes could be procured.

The total length of the suction was unnecessarily great, giving the pipes an inclination of 27° from the horizontal in the deepest work, and it was decided to leave out one of the 20-ft. lengths. This involved changing the davits and shears for the after hoist. This was done on the "Atlantic" before she came to New York, and on the "Manhattan" in May, 1905; the latter at cost of $533.

A steel pipe was designed and made of ⅜-in. steel plate with welded seam and with cast-steel flanges welded on. It takes from six to ten weeks to get these pipes made, and the first installment was received in May, 1905. These pipes have proved very durable; several of them have been bent by the dredge drifting over them—a sometimes unavoidable occurrence in night or in rough sea—two of them have worn through and one, which was nearly worn out, has broken. The pipes are now stronger than the flange bolts, and if any obstruction on the bottom causes a break, it occurs in the bolts, which are easily replaced. The cost of the pipes was at first $258 per 20-ft. length, subsequently reduced to $250 in consideration of a variation of ¼-in. in length allowed and the resulting saving in machine work. When bent, the pipes can often be turned the other side up and used for a while, and afterwards, unless the flanges are badly twisted, be repaired and made nearly as good as new by welding in a new piece of steel plate and reforging and machining the flanges. The cost of such repairs varies from $110 to $200 for a 20-ft. section.

In the flanges for the rubber suctions, the bolt holes were unevenly spaced to avoid a lug for the bridle-chain, and one end of one steel pipe had to have bolt holes bored to fit. To obviate the need of keeping two kinds of steel pipe on hand, small union-pieces, 10 ins. long, were made, with bolt holes in one flange to fit the rubber suctions, in the other to fit the pipes. These unions cost $40 each; none of them has yet worn out or broken.

The flexible connection between the elbow and the steel pipe, as in all dredges of this kind, has been unsatisfactory. Twelve rubber hose were furnished by the contractors who built the dredges; they were 4½ ft. long over all, two in use on each side of each dredge, with four spare ones. They were made of an inner tube of rubber, ¼ to ⅜-in. thick, covered with six layers of duck frictioned both sides, and wound with a ¾-in. galvanized steel coil, laid up 2½ ins. between centers, the intervening spaces filled with rubber composition. This was then wound with six or eight layers of frictioned duck and covered with a thin outer coat of rubber.

For suction hose, the duck inside the steel coil was a source of weakness, the suction separating it either between its own layers or from the adjacent rubber. Galvanizing the steel coils was an unnecessary expense, as they were wholly encased in the rubber. After several different trials the best results were obtaind from a hose having the inner tube of tough rubber, with the coils of spring steel, not galvanized, immediately over it and the duck wholly outside of the steel.

During the past year rubber hose have been purchased under contract, the original specifications calling for an inner tube of rubber ¼-in. thick, overlaid with a ¾-in. steel coil covered with eight layers of duck, with an outer coat of rubber. The cost of these was $95 for each 4½-ft. length, the United States furnishing the steel flanges. The inner tube often wore out, and as an experiment it was made ⅛-in. thick, with some minor changes at the flange fastenings, at a cost of $140 per hose.

The manufacturer took a personal interest in adapting his hose to the dredging and visited the dredges to see the conditions under which they work. He was asked to design a hose which, in his judgment, would be the best that could be made, and he presented a plan for filling between the steel coils with the grade of rubber used for the inner tube, and placing thin rubber sheets between the layers of duck. The cost of this hose was $190. Three of them were ordered but they did not prove economical. The maker wished another trial and offered to furnish a hose of this kind at $95. This was allowed, but the result was the same.

After June 1, 1905, the forward one of the two pieces of rubber hose in each suction was removed and replaced with a steel pipe of the same length; and thereafter records of the durability of the different pieces of hose were kept. The average cost per 1,000 yds. of material passing through is based upon the price paid for the hose, plus $50, the latter being added for the lost time required to replace a hose (two hours' time at $600 per day—it should be more nearly $800 per day).

Kind of hose.	Number used.	Total cu. yds. passed.	Cost per 1,000 cu. yds.
$190 type	4	377,000	$2.55
$140 type	14	1,375,000	1.94
$95 type	11	668,000	2.39

On the basis of these figures the $140 kind has been considered the most economical. Hose of other makes have not shown as good results.

In preparing specifications for hose an effort was made to learn the compositions of the rubber used, but manufacturers are not willing to give it. Following is about the extent of the information which could be obtained: Pure rubber alone is not used for any manufacture unless it be for very soft pencil erasers. Litharge, magnesia, whiting, sulphur, oxide of zinc, etc., are used to improve the composition and give it "body," and if properly used should not be classed as adulterants. Inferior rubbers, some of them nearly as good as Para rubber, are brought from Central America. When made up it is hard to tell the difference except by durability. Rubber substitutes are gums, mainly from Africa, which are elastic when fresh, and may improve the appearance of some manufactured goods; when old and dry they become brittle, sometimes enough so to be powdered.

Rubber suitable for the lining of such suction hose as these dredges require ought to stretch, in small samples, to six times its original length and return readily; pieces ½ to 1 in. thick, bent 180°, ought to spring back very quickly. Picking off small pieces from the edge with the finger nails tests its strength and toughness.

The amount of residuum left by burning is of little value as a test, when the ingredients are not known; some compositions having as high as 40% residuum may be better than others having 5 or 10%. Sulphur and substitute gums leave no appreciable ash.

No market is found for the worn out rubber or the old steel coils. Makers prefer that the flanges be sent them with the old rubber removed.

Plans have been prepared for ball and socket joints, for use instead of the rubber hose, for it seems that something more durable than rubber ought to be devised for this necessary part of the equipment. Trial of them has been delayed to await the result of similar trials in progress elsewhere.

DRAGS.—The dredges were each provided with three drags; two of a pattern in which the 20-in. pipe broadened out to 5 ft. width and turned over in a hook, with an opening in the bottom 8 × 60 ins., fitted with a scraper to collect material and with an apron forward of the opening to prevent the hooks sinking too deep into the bottom, or catching on obstructions; and one of a pattern designed by Mr. J. P. Allen, Assistant Engineer, which differed from the other in spreading out to a flat surface on the bottom without turning over as a hook, having a 9-in. opening at the after end the full width of the drag. It also had a scraper and had adjustable openings in the top to admit water where necessary to flush the dredgings.

The hooked drags were used first. They worked well in the loose sand on the outer face of the bar, pumping it at rates from 11 to 15 yds. per min., but when the dredges moved to the inner face of the bar where the sand was more compact, contained some clay, and was covered with mud, stones and refuse, the rate fell to 6½ or 7 yds. per min.

There was a prejudice among some of the experienced employees against using the Allen drags, with no reasonable ground assigned except that they were heavier. When the old drags needed repairs the Allen drags were put in use and proved fully as efficient, so they were kept on. The flat under side of the drag forward of the opening was drawing over the sand of the bottom and gradually wore through. The drags were kept in use and they kept wearing away on the bottom, with the result that the more they wore away the more the pumping average increased. When we had them repaired we left open the parts which had worn through, and strengthened the drag by adding longitudinal steel bars about 3 ins. sq., like runners, with two cross-bars for strength and for keeping out large stones. The results continued so satisfactorily that the pattern was cut away and bars added to it; castings from the altered pattern showed a pumping rate nearly twice that of the original drags of either pattern.

This is best shown by the work of the "Atlantic" during March, 1906. New drags had been ordered for delivery in February, but were delayed by strikes at the foundry, and the "Atlantic" began work with two of the old hook drags. One of the new drags arrived March 19

and was put on, using one new one and one old one. After March 24 both new drags were in use.

Cubic Yards of Sand, etc., Pumped per Minute by Dredge "Atlantic," in March, 1906.

	Maximum.	Minimum.	Average.
Mar. 5-17: 2 old drags...	10.9	5.2	7.9
Mar. 19-22: 1 old and 1 new drag.....	13.1	8.7	10.6
Mar. 26-31: 2 new drags...	16.0	11.6	14.0

Had the new drags reached us before March 1, and had the "Atlantic" worked her actual number of hours (381⅛) with them at the rate of 14 yds. per min. pumping, allowing her actual time per 1,000 yds. for going to sea, dumping and returning (62.7 min. per 1,000 yards), she would have excavated 170,540 yds., or 31,620 yds. more than she did, in fact, excavate. At the contractor's price of 9 cts. per yd. this would amount to $2,846, or more than the cost of ten new drags.

Considerations like this make one realize the importance of promptness in keeping the plant supplied with the best available appliances for work.

The new drags differ essentially from the old ones in that they seem to depend wholly upon the suction force for loosening the bottom, though the runners and the weight of the drag may be of some effect. What changes this drag may need for work in clayey material are not yet determined. It was developed experimentally upon work in progress, and upon this work it has almost doubled the amount pumped in a given time.

After running over the sand day and night for from six to eight weeks, these drags get worn so much on the bottom as to need repairs, while the top does not wear at all. A new pattern has been made having the bottom a separate piece; castings from this are now being finished.

PUMPS.—The pumps are 20-in. centrifugals, one on either side of the ship, with suction on outboard side only and with vertical discharge. The shell or volute was made of cast iron, in one piece, of rounded cross-section, 2½ ins. thick, 9½ ft. diameter over all, and weighing about 7,500 lbs. There was a 4½-in. siphon opening in the top of the shell. The back-head was a heavy casting attached to the bed plate, and protected from wear by a plate steel liner ½-in. thick. The suction head was a casting 7 ft. ½-in. diameter on the face against the shell, reducing by a curve to 3 ft. 2 ins. where it joined the suction pipe. It was 1¼ ins. thick and ribbed, and was provided with a cast-iron liner 1 in. thick, separated from the head by about ¼-in. space, except at the ends which were machined to fit. The suction head and liner had a hand hole 12 × 14 ins., also fitted with a liner.

The runner, or impeller, was a cast-steel disk with four vanes 10 ins. wide and tapering from 1⅜ to ⅞-in. thickness. Each vane had a ⅝-in. steel liner bolted to its forward face. The vanes were sharply curved backward in an arc of about 100°. The disk was perforated with 60 1½-in. holes and four triangular openings near the hub, said to be for the purpose of equalizing the pressure on both sides of the disk. The vanes were designed for a very close clearance, about ¼-in., both at the sides and at the lip of the discharge. The vanes were open, that is, not "shrouded" or enclosed along the suction edge. The runner ordinarily makes about 180 r. p. m. and works with a vacuum of 24 to 27 ins.

So much detail of description is given because a great deal of trouble was had in maintaining the pumps. They were probably excellent machines for pumping water or light sand; they were not found adequate to the rough usage which they met in excavating Ambrose Channel.

The first weakness to develop was in the suction heads, which cracked under the impact of stones. Those cracks oftenest occurred at the hand hole. This hole was made for examining the inside of the pump in case of trouble, to find out the cause. It was never found possible to remove the cause without taking off the suction head, and as the hand hole served no useful purpose it was subsequently omitted. The liner, intended to protect the outer part of the suction head, proved in fact an injury to it; itself thinner than the head, it broke more easily, and the broken part caught the impact from stones more forcibly than a smooth surface. When a liner broke the first notice of it was the cracking of the head itself. This would not necessarily be true if the parts wore out; but it was not a case of wear but of breaking. The liners, as separate pieces, have been abandoned, head and liner being cast in one piece; the increased cost due to weight offsets the saving in machine work, and the one-piece suction head lasts five times as long as the original type.

The pump shells proved unequal to their duty. They did not wear out fast, but cracked under the blows of heavy material passing at the rate of 50 to 60 ft. per sec. Six of these shells have been broken, and in every case the first crack appeared on the top, radiating from the siphon opening. In one case a stone went completely through the "Atlantic's" shell, flooding the port engine with water and sand. In only one case has a crack appeared below the middle of the shell.

A new pattern for pump shell was made which omitted the siphon opening, made the top thicker and divided the shell into two parts flanged and bolted together along a horizontal line through the center. As the old shells broke the new ones were put in, the first Nov. 16, 1905, and the last (fourth) April 25, 1906. None of them has yet cracked.

These new shells weigh about 10,000 lbs.: 4,700 lbs. in the upper piece and 5,300 in the lower. From past experience the lower piece is expected to outlast three or four of the upper ones. Shells in two parts are much easier to handle in mounting them in place.

The following show the amounts of material [cu. yds.] passing through each pump shell, up to June 30, 1906:

	"Manhattan." Starboard.	"Manhattan." Port.	"Atlantic." Starboard.	"Atlantic." Port.
Original shells	237,372	380,092	429,437	347,002
Original shells thicker at top	523,146	511,995	.....	.....
New shells, without siphon (not yet cracked)	354,501	223,821	581,872	664,219

In closing the siphon opening in the shell, the siphon was attached to the discharge pipe just above the pump, a better place for it.

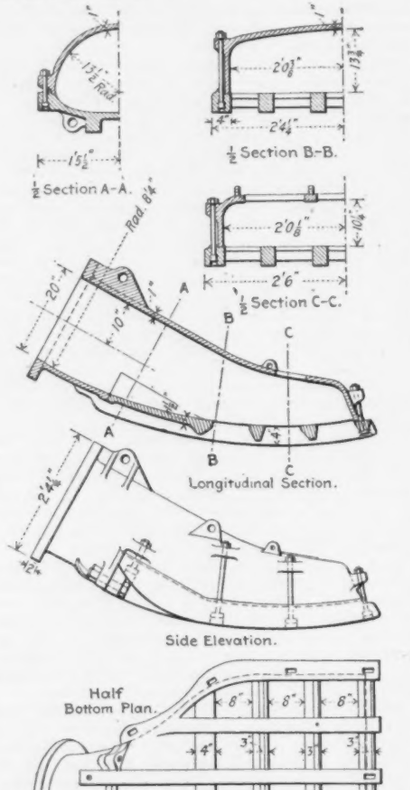


Fig. 2. Details of New Drag Used on U. S. Dredges in Ambrose Channel Work, New York Harbor.

The back heads of the pumps have been satisfactory so far. The steel plate liners protect the head. They wear out themselves in about six months, but are not expensive or difficult to replace.

The runners wear down quite rapidly at the ends of the vanes and at the exposed edge opposite the disk. The liners on the vanes are not practically renewable; when they wear out the vanes themselves are too far gone to hold new ones. The close clearance for the vanes seems to be unnecessary on a dredge of this type; originally ¼-in., the wear on the vanes increases the clearance to 1½ or 2 ins. on the edge and to 4 or even 6 ins. on the ends before any reduction in the output is noticeable. The runner turns up 10 to 20 revolutions more as the resistance lessens, and seems to accomplish equally good results. We have run them until the vanes wear off 8 ins. at the ends and full 3 ins. along the edges, leaving about 60% of the original surface, though there is then a considerable loss of efficiency, probably 10 to 20%.

The openings in the disk are not necessary. They let sand and gravel in against the back head. In every case they have been plugged before using the runners.

The pattern of the runners has been altered to provide a shrouding or enclosure for the vanes, and to thicken the vanes instead of using liners. Castings from the new pattern are now being finished.

Our rather short experience shows, as might be expected, that the requirements for efficiency in a pump lifting water are not identical with those best adapted to work in sand, stones and other heavy materials. The work of a water pump is measured by the quantity of water delivered, or the height to which it is raised, or both. In a dredging pump the water is not measured; it may be regarded as dead weight, and the least which will flush the dredgings and keep the pipes free is the most economical. The height to which material is lifted is usually not great, but it is of the first importance to have a machine which will stand the rough work.

These conclusions seem fairly established for such rough material as we have in Ambrose Channel: (1) Cast liners are of no use on parts exposed to impact of heavy materials; it is better to get protection or durability by thickening the main casting. (2) For a pump with horizontal axis and vertical discharge the weakest part of the shell is near the top. (3) No siphon hole, hand hole, or other unnecessary opening ought to be made in the pump shell. (4) A close clearance for the vanes is a matter of not much importance, when the back pressure is low.

HOISTING ENGINES.—The dredges were equipped with two hoisting engines, reversing gear, each having two drums and galvanized cable for raising and lowering the suction pipes. The cable for the forward end of the pipe was ¾-in. and for the after end, 1 in. The engines were bed-plated on the lower deck, aft of the after bin, one on each side of the ship and about 5 ft. from the outer hull plates. A leading-block outside the plates guided the cable through an opening in the plate to its drum. The position of the engines, so near the side of the ship, afforded a very short lead to the cable, so that it chafed the plates of the ship and rode over itself on the drum. This wore out the cables quickly and created oblique strains on the drum bearings.

On the "Manhattan" two idler pulleys were placed on a shaft near the middle of the ship and the main cables were carried over these and back to the drums. On the "Atlantic" the hoisting engines themselves were moved over nearly to the middle of the ship. Either method appears satisfactory so far. A plan was considered for carrying the cables across the ship so that the starboard engine should carry the port cable and vice versa. This would require carrying the steam connections across also, so that each hoist should be controlled by a valve near by. This plan was not adopted on account of the delay it would cause housing in the cables and making connections.

When the original galvanized cables gave out they were replaced with cast-steel hoisting rope of the same size. This is stronger and more durable than galvanized cable. It requires slushing down with grease at least once a day to prevent rusting. Subsequently we reduced the size of the cables, substituting ¾-in. for 1-in. and ⅝-in. for ¾-in. The smaller cables take the turn on the sheaves better and last quite as long as the larger ones.

DISCHARGE PIPES.—These pipes rise vertically 2½ ft. from the pumps, then divide in a Y casting and carry horizontally aft along the roof of the engine-room for 21¾ ft. and forward along the roof of the boiler-room 31¾ ft.; then by a reversed bend of two cast-iron pipe bends, with a further rise of 5½ ft. through the deck, to the bins.

The engine-room pipe was in one piece. The boiler-room pipe in two pieces, one 11¾ ft. long and the other 20 ft., the latter being identical with the suction pipes. These pipes wear fastest on top close to the joint with the Y. Those in the engine-room have, in every case, worn out faster than those forward, but no reason for it is known. To avoid rejecting a long pipe when but one end of it is worn, new pipes have been ordered of lengths 5 ft. and 6 ft. 9 ins. On account of scant space it would be difficult to remove and replace the 20-ft. pipe in the boiler-room; it may have to be cut in two when it is taken out.

If the discharge pipes were carried vertically above the deck and then branched, small leakages above deck would be immaterial, and the pipes could be patched as long as they would hold together. Below deck, and especially in the engine-room, leakage of sand has to be avoided. Above deck, however, the pipes themselves would be more in the way than where they are now.

SAND BINS.—The dredges have two bins, one forward of the boilers and engines and one aft. Each bin has eight discharge gates, opened and closed by rods threaded into large hand wheels, and also arranged to operate by steam from worm gears on longitudinal shafts. The bins are held together by numerous tie-rods and beams and the deck beams cross the top of the bins; the tie-rods and beams also hold the gate-rods in place. Each bin has four overflows under the deck to carry off water, and has a coaming 18 ins. above the deck. Full to the top of the coamings the "Manhattan's" forward bin would hold 1,271 cu. yds. and her after bin 1,205 cu. yds.; total,

2,470 cu. yds. The "Atlantic's" bins measure up 2 yds. more in total. Eleven feet of the after end of the forward bin is covered by the floor of the steering engine-room.

Such large bins are rather weak. The tie-rods prevent their spreading, but the pressure of discharging sand frequently binds and sometimes breaks the rods. Apparently it would have been better to divide the bins by one cross and one longitudinal bulkhead.

The bin overflows were placed so low down that the dredges could not readily carry a full load. They were boxed in in July, 1905, so as to make the discharge at about the deck level. Before the overflows were so boxed in the average load was 1,485 cu. yds. in 368 loads; since then 1,555 loads have averaged 2,045 cu. yds. Of this difference, 560 yds., it is estimated that 100 yds. is due to the changes, the rest being due to the general improvement in working. The cost of taking dredgings to sea and returning to the cut has been 1,488 cts. per cu. yd. It does not take noticeably longer to carry a full load to sea than a scant load, and the difference of 100 yds. in each of 1,555 loads, at 1.488 cts., is $2,300. The cost of boxing in the overflows was $175 for each dredge.

It is impossible to load the dredges up to the tops of the coamings, partly on account of the overflows, partly because it would cover the decks with sand, and partly because the heavy material now being dredged would sink the ships too deep. In still weather they can carry over 2,100 yds.; the largest load yet carried is 2,299 yds.

The discharge pipes from the pumps are at the sides of the bins. It was found necessary to build distributing chutes to drop sand near the middle, in order to keep the ship trimmed. On six occasions, when one pump has broken down, the dredges have worked with a single pump and have kept on an even keel by means of these chutes. A single pump works with about 60 to 65% of the output of two pumps.

OUTBOARD BEARINGS OF PROPELLER SHAFTS.—The after part of the shaft is a piece of forged steel 35 ft. 9¼ ins. long and 10¼ ins. diameter, the outboard end of which extends beyond the hull 21 ft. 10¼ ins. and is supported by two brackets, one with an 18-in. bearing, and one next the wheel with a 30-in. bearing. The entire outboard part of the shaft was sheathed with brass sleeves, shrunk on, ½-in. thick except at the bearings, where it was ⅝-in. The wheels clear the after bearing by about an inch.

While the dredges are pumping, the water behind the overflow is charged with mud and fine sand. This gradually works in at the bearings between the brass sleeve and the babbitted bushing of the bracket, grinding away the metal until the shaft becomes loose. When the play becomes as great as ½-in. the shaft "pounds," and the wheel cannot be driven at full speed with safety. To repair it it is necessary to dock the ship, take off the wheels and draw the shafts and put in new brass sleeves and rebabbitt them, at a cost of from $2,000 to $2,400, and seven or eight days' lost time. In Ambrose Channel these bearings last about four months, working continuously day and night.

When the "Manhattan's" outboard bearings were last repaired brass stuffing-boxes were placed outside each bracket, packed with flax packing held in by a gland, and the hub of each bracket was tapped on top and connected by a brass pipe with a pressure oil cup inside the ship. The cup is filled with oil and every hour a turn on the pressure-screw is taken to force the oil down into the bearings. The stuffing-boxes and glands are made in halves so that they can be taken off and repacked without drawing the shaft. At the propeller end of the after bearing the clearance was not sufficient for a stuffing-box, and a simple gland was inserted into the hub and packed. This cost about $900. It has not been in use long enough to test its durability. If it is not successful another device will be tried for protecting the bearings.

It would seem worth while in building a dredge for this class of work to house in the entire shaft out to the outer bearing, and to give the wheel a clearance of 5 or 6 ins. so that a stuffing-box could be placed at the only joint which would then be exposed.

OTHER PARTS OF THE DREDGES.—The dredges were originally provided with water-tanks holding about 14,000 gals. On account of the distance of Ambrose Channel from fresh water supply, it was found necessary to convert part of the fore-peak chain-locker into an additional water-tank. The lockers were apparently built with this in view. The dredges are now able to carry a full week's supply of coal and water without returning to the dock.

Chafing plates have been required on the sides of the ships when the suction pipes and hoisting cables chafed against the ship's plates. It was found necessary to widen the rudders, in order to improve the steering. The rudders were placed in the quick-water between the wheels, where they are not as effective as they might be. Perhaps this could have been bettered by making the shafts about 5 ft. shorter and bringing the wheels more forward.

The boiler arrangement is an excellent one. Three of the four boilers keep up steam without jet or artificial draft, so that each boiler has every fourth week for rest and cleaning. The Manhattan has just come in (June 30) with the fire-box crowns in one of the boilers "dropped down." Investigation is being made now, but the dredge will be able to work with her three other boilers during preparation for repairs.

ESTIMATES OF EXPENSES.

In September, 1905, a preliminary estimate was made of the total expenses which each dredge would have to meet and pay for out of the results of the work, if operated by a contractor. This estimate, $12,500 per month, has proved so nearly accurate that no general revision of it has yet been made. It is as follows:

MONTHLY OPERATING EXPENSES.

Payroll	$2,660	
Coal	2,480	
Water	60	
Subsistence	700	
Engine-room supplies	150	
Other supplies	250	
Casual repairs	500	
Total per month		$6,800

ANNUAL CARE OF PLANT.

Docking and painting, twice a year	$1,250	
Renewals of equipment	12,150	
Miscellaneous	1,000	
Total per year	$14,400	
Average per month		1,200

ANNUAL FIXED CHARGES UPON ORIGINAL COST, ESTIMATED AT $341,800.

Sinking fund, towards original cost, 10%	$34,180	
Interest, at 4%	13,672	
Insurance risk, 2%	6,836	
Fixed charges per year	$54,688	
Average of fixed charges, per month		4,500
Total, per month		$12,500

The sinking fund is meant to cover depreciation. The insurance covers risk only, not what would be actual cost. For steel boats not going more than five miles from harbor, it probably more than covers any risk incurred. To meet these charges out of excavations which would otherwise be made under contract at 9 cts. per yard requires an average output for each dredge of 138,900 cu. yds. per month—277,800 yds. for the two dredges. Any excess over this, a contractor would apply to expenses of administration and to dividends.

The twelve months ending June 30, 1906, show a monthly average, for the two dredges, of 316,200 yds.; the last three months' average is 458,319 yds.; in the last month, June, 1906, 535,692 yds. were excavated. The work of June, 1906, is the largest month's work which this plant has yet done. Under favorable conditions as to kind of material and with little lost time due to repairs, etc., it may perhaps be exceeded, but it is doubtful whether the plant can permanently maintain so high an average.

MANNER OF MAKING REPAIRS.

The making of repairs under a general contract in advance, at stated prices per hour for different classes of labor and machines, and at unit prices for materials, was tried and found unsatisfactory. At the very start, comparing bids assumes that the services of a mechanic and a machine were to be measured by the price, regardless of what the man and machine may be capable of: that a machinist at 35 cts. per hour is more economical than another at 40 cts., or that a lathe at 45 cts. is better than another lathe at 50 cts. It is impossible to keep the shop men at work industriously, to tell whether delays are unavoidable, and to keep a time record which is indisputable. In practice, the cost was found to be excessive, and the plan has been given up whenever it could be, in favor of a stipulated price for each piece of work required. Even in cases such as repair of the outboard bearings when the work required cannot be known until the ship is docked, it is found economical to pay for a day's docking and invite bidders to come and examine the ship, drawing up specifications and receiving bids on the spot, rather than to make an agreement involving work by the hour.

Small items of necessary work will develop during general repairs which must for economy's sake be done at the time. It is better to get a price from the shop making the other repairs than to attempt any competition involving delay, or to enter into a time agreement. It may be said to the credit of the New York shipyards and repair shops that, whether their prices have been high or low and the work profitable or otherwise, they have not yet tried to do a poor piece of work upon these dredges. Perhaps the conditions would be different in places where there is little or no competition.

No satisfactory way has yet been found for insisting upon the time limit for making repairs. To claim the value of the dredge's services, $800 per day, as liquidated damages, would drive out bidders. Some incentive to haste can be offered by considering promptness on previous work as an item to be considered in accepting bids.

COMPARISON WITH CONTRACTOR'S PLANT.

The contractor's plant consists of two steel dredges, somewhat larger and more costly than the Government's dredges, and each capable of carrying about 3,000 yds. to a load. They have a single 48-in. suction, lowered through a well in the middle of the ship, and they pump while at anchor, excavating a deep basin under their suction nozzle. This type of dredge was developed at Liverpool, England, and seems to be adapted to local conditions there, where the channel bottom is a fine quicksand, which runs into deep holes as soon as they are made. The bottom in Ambrose Channel, on the contrary, is a rather hard-packed sand in which overdepths remain a long time. While working on the outer face of the bar, in the loosest sand and with the shortest run to dump, in the year ending June 30, 1902, the contractor's dredges took out 5,015,568 cu. yds. of sand, of which 923,176 yds. were from below the required depth, and 4,092,392 yds. were paid for. With this exception they have never taken out as much as the Government plant did last year, 3,794,399 cu. yds., and during the last year, working on similar bottom, the contractor removed but 2,364,889 cu. yds., overdepths included.

We are accomplishing more work and better work with a smaller and less costly plant than the contractor's, and no one who has noted the work of the two plants under similar conditions doubts the superiority of the type of dredge in the Government plant over the Liverpool type for work such as that in Ambrose Channel. But it would not be fair to ascribe the difference in result altogether to difference in kind of plant. We have a better management, system and personnel, from the Chief of Engineers and yourself down to the deckhands and sailors; the plant is kept in better order; the work is done more harmoniously and industriously, and we shall continue to show that Ambrose Channel could be dredged profitably at 9 cts. per cu. yd.

GARBAGE AND REFUSE TRAINS, hauled by electric locomotives, will be used at Dublin, Ireland, in connection with a new refuse collection and disposal system. The system was described by Mr. W. F. Goodrich, of London, in a paper on 'Refuse Disposal in 1906," read before the Cork Congress of the Royal Institute of Public Health, as follows:

During the daytime, instead of carting all the refuse to the destructor in Stanley St., sufficient only will be carted direct there from the destructor to keep the plant in full work. The remainder of the refuse will be carted to the tramway depot at South Gloucester St. and tipped into large tank tipping wagons; during the night these vehicles will be hauled by electric locomotives over the tramway track to the destructor works. Each locomotive will convey a train of tipping wagons containing from 75 to 80 [long] tons of refuse, so that in a single journey the whole of the refuse not carted during the day may be taken direct to the destructor works. While only one tramway depot will be used for refuse storage at first, it is intended later to equip other depots; these, with the first depot, will be used not only for storing refuse, but also for storing mud and street sweepings, which, like the refuse, will be stored in tank tipping wagons and taken by electric locomotives to the Fairview Sloblands—suitable land for reclamation, which will take 70,000 [long] tons of mud per annum for twenty years, the ultimate intention being to convert this tract of 57 acres, which faces the sea, into a public park. This is a scheme of which the Dublin authorities may be justly proud. In so far as the haulage of refuse over the tramway track by electric locomotives is concerned the scheme is unique and of the highest interest; so far as I am aware, Frankfort-on-the-Main being the only other city in Europe where a similar method of refuse haulage has been adopted.

The new destructor plant will include two four-grate Meldrum destructors of the regenerative back-fed type, having a guaranteed capacity of 120 long tons per 24 hours. These will supply steam to two Babcock & Wilcox boilers, each having 1,741 sq. ft. of heating surface and working at a pressure of 200 lbs. per sq. in. The refuse will be stored in two hoppers, each 7 × 22 ft. × 11½ ft. deep, placed at the back of the cells. An overhead railway, with eight traveling clinker cars, will be provided. A separate building will house a mortar mill and also "a tin crushing revolving screen," the latter for handling tin cans. The contractor guarantees an average temperature of 2,000° F. in the combustion chamber, and a steam production of 11,200 lbs. per hour at a working pressure of not less than 175,000 lbs. per sq. in.; also, a labor cost per ton of refuse destroyed, taking local wage rates into account, of 6½d. per long ton (11½ cts. per short ton).

THE WATER SUPPLY OF SCRANTON, PA., is adequate, but not available in sufficient quantities in all localities owing to faults in the distribution system, according to a report just made by the Committee on Fire Prevention of the National Board of Fire Underwriters (135 William St., New York). The fire department is characterized as decidedly weak in men and also in engines of suitable capacity. There is no municipal control of electric risks. The general conflagration hazard is made small by the division of the congested value district by two 100-ft. streets and by the low average size of buildings; in the congested value district, however, there are severe local hazards, owing to structural weaknesses, conflagration breeders and narrow streets.

TRACK CONSTRUCTION FOR RAILWAY TUNNELS.

It is the universal practice in this country to use the ordinary type of track construction in tunnels as well as in the open, although often the conditions are such that it would be probably economical and certainly advantageous in other ways to adopt some more permanent type of construction which would serve the double purpose of being more substantial in itself and requiring less maintenance work to keep it in good condition. The conditions affecting track and maintenance of way in tunnels are discussed in our editorial columns, and we present herewith some particulars as to practice, experience and opinions on railways in this country and in England. It will be seen that with the exception of the case of a circular tunnel (where some special system was practically unavoidable) the usual method is to lay the rails on ties in ballast, as in the open; the ballast cross section differs to some extent from that on the open roadbed, however, owing to the form and arrangement of the floor and ditches. In double-track tunnels with inverts there is usually a considerable depth of ballast, sometimes as much as 4 ft. 6 ins. at the middle; in some small flat-floor tunnels, on the other hand, it is only possible to use about 6 ins. of ballast under the ties, owing to the necessity of giving sufficient headróom or clearance for large cars. In fact, in railway tunnels, as well as in underground railways (the track construction of which was dealt with in our issue of Aug. 2) the question is largely that of whether or not a ballasted floor should be used. The elimination of cross ties is another point to be considered, as is the protection of rails against corrosion, since in wet or damp tunnels the corrosion due to moisture, smoke and gases from combustion, and to the presence of cinders and other impurities in the ballast is sometimes very serious. With this general explanation of the matter, we present below the particulars as to certain American and foreign railways.

BALTIMORE & OHIO.—This road has numerous tunnels, but in all of them the track construction is the same as in the open, and there is no experimental track. The standard track has 12 ins. of ballast under the ties, but in many cases the tunnel track is not up to this standard, owing to the rock bottom or floor in tunnels of small section which were built when the rolling stock equipment was of much smaller size than at present. There is found to be considerable difficulty (and consequently additional expense) in the maintenance of tracks in tunnels, some of which is due to the short life of the rails. Thus there are some tunnels in which 85-lb. rails have to be renewed every two years. This is not entirely due to the wear, for, although the wear is considerable, the rails fail from some other cause; after about two years' service they commence to break and go "all to pieces." It has not yet been determined what action has taken place in the rails which causes them to fail in this manner. Pieces have been removed for examination and test, but so far no special light has been thrown upon the subject.

It is also found to be much more expensive to handle material in the long tunnels than on the open track. This is particularly the case in two of the very long tunnels, owing to the fact that they have only a single track. These are the summit tunnels of the Alleghenies on both the main lines. Each of these tunnels is nearly a mile long, and one of them is of small section. Besides the difficulty of handling material, it is difficult for the men to work, owing to the smoke and gases, as the tunnels are not well ventilated. In order to reduce the work in these tunnels, experiments have been made with a small track built in the ditch on one side. To start with, a concrete ditch was made along the entire length of the tunnel; immediately over this ditch, was built a track of 30 ins. gage, set down low. On this ran a special car which had low sides, the top of the car being level with the top of the main track rails. After this concrete ditch was built and the track constructed, the gangs worked through the entire length of the tunnel, cleaned the dirt from stone ballast, and ditched the other side, using these small cars for removing all the material. This method served well, as the men were able to work at all times, and without blocking the main track, or interfering with traffic. The car was handled entirely by men, no other power being used. This car is now being used to handle material into and out of the tunnel for track repairs. It has proved so satisfactory that arrangements are being made to repeat the performance in the other tunnel over the summit of the Alleghenies.

To protect men at work in the tunnel, there are safety niches or refuges in the sides of the tunnels at frequent intervals; the men are supposed to go into these whenever a train enters the tunnel, as in long tunnels it is not always possible to tell on which track the train is running.

The ordinary work in the tunnels is performed by the regular section forces. When rails are relaid or some large work of that character is required, an extra force is employed or the regular force doubled up so as to get the work through in a short time. The average movement through these two tunnels per day is as follows: No. 1, 50 engines each way and same number of helpers, 850 to 900 cars each way per day; No. 2, 40 trains with 16 helpers and 1,160 cars eastbound, 34 trains and 600 cars westbound.

NEW YORK CENTRAL & HUDSON RIVER.—The ordinary track construction is employed in tunnels, but different types of construction

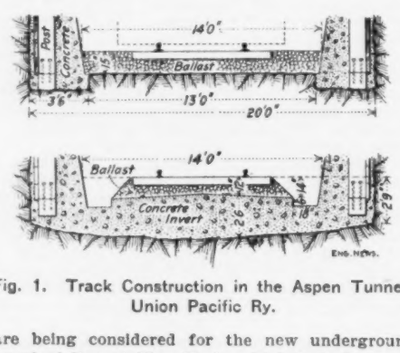


Fig. 1. Track Construction in the Aspen Tunnel: Union Pacific Ry.

are being considered for the new underground terminal line at New York, which is to be operated by electricity. At present the terminal line is operated by steam, and the tracks are laid with 100-lb. rails in 33-ft. lengths, secured to the ties by Goldie spikes. The rails are laid with three-tie supported broken joints, spliced with 36-in. splice bars and six bolts. The ties are 6 ins. thick, 8 ft. long, and from 9 to 10 ins. wide, and there are 20 ties to a rail length of 33 ft. Stone ballast is used, 12 ins. deep under the ties, and is cleaned every year by turning it over with forks. The maximum weight of locomotives is 107½ tons (171 tons including tender); these engines have six axles, of which three are driving axles carrying 47,000 lbs. each.

NORFOLK & WESTERN.—The track construction in tunnels is the same as in the open. In the Elkhorn tunnel, 300 ft. long, there was originally trouble from the corrosion of the rails, due to smoke and gases as well as to dampness. Some years ago, however, this tunnel was equipped with a ventilating plant (Eng. News, May 23, 1901), and after this had been put in operation the corrosion ceased. It seems, therefore, that trouble of this kind may be eliminated by keeping tunnels well ventilated. The expense of keeping up track in tunnels will always be greater than on outside work. However, in well ventilated tunnels (such as the Elkhorn) there is now no trouble in keeping men in the tunnel and thereby keeping the track in good condition. This is especially the case in view of the fact that numerous manholes or refuge bays are always provided for the convenience and safety of the men. These refuges are about 200 ft. apart on each side, and staggered, so that there is a refuge at every 100 ft. Some of the single-track tunnels have as many as 90 trains per day, and some of the double-track tunnels have rather more.

PENNSYLVANIA.—In sending us some information as to tracks for tunnels, Mr. Joseph T. Richards, Chief Engineer of Maintenance of Way, states that the wear on street railway track with heavy girder rails on concrete foundations and carrying comparatively slow and light cars is greater than on steam railway track with lighter rails carrying heavy trains, the lighter rails being laid on wooden ties and a less rigid substructure. This can hardly be accepted as a very definite argument against a permanent track construction in tunnels, and does not take into account the effects of corrosion upon rails which are undoubtedly experienced in ordinary tunnels. Furthermore, it does not take into account the greater difficulty, expense and danger of maintenance and renewal work in tunnels. With this comment we quote Mr. Richard's letter as follows:

> Engineers are making a study of what is termed permanent track construction, but so for as I have been able to see, nothing of the kind has been adopted that will stand longer than first-class stone ballast and wooden cross-ties with heavy tie-plates to support the rails. Concrete and girders form too rigid a roadbed for fast speed trains. The impact crushes the concrete, and the track is too solid to begin with, so that it seems absolutely necessary to have a cushion between the rolling stock and the roadbed. The ballast and the wooden tie form this cushion. The subway of Philadelphia and the small tunnel system under Chicago (in both cases a slow speed track) have rails on metal supports embedded in the concrete. This may do for light cars and slow speed, but in the Philadelphia subway wooden supports have been put in under the rails for the high-speed lines [Eng. News, Aug. 2, 1906].
>
> A wooden cross-tie, if creosoted and protected with a heavy plate will last 20 years. The engineer of maintenance of way of the London & Northwestern Ry. (England) informs me that they get an average of 21 years' life out of a creosoted tie, with a heavy plate [chair.—Ed.] to protect it and a felt cushion between the plate [chair] and the tie, and they have ties in their side tracks and yards lasting 30 years. So the wooden cross-tie is not the perishable article that we generally hear talked about. Twenty years is longer than anything about a railway lasts; longer than the rails, the car wheels, axles, trucks, locomotives or any part of the rolling stock. While we believe it is necessary to have a cushion under the rail, the wooden tie is the most fortunate part of our construction, and I do not believe we can get away from it or should desire to get away from it, provided we place a further cushion of ballast under the tie to make the elastic track, which is necessary, in my opinion, for fast speed trains.
>
> We find in cities the trolley lines using rails as heavy as 140 lbs. ped yd. They have built concrete foundations for this heavy rail. Their speed is slow as compared with the speed of steam railway trains and their cars are of light weight, comparatively. Yet this 140-lb. rail does not keep in surface or wear longer than 90 and 100-lb. rails carrying the heavy railway train, where the lighter rail has the wooden tie, and less rigid substructure.
>
> As to the question of corrosion of rails, there is no reason why this should take place in a tunnel more than along the seashore or in the coal mining districts.

PHILADELPHIA & READING.—This road has no special track construction in tunnels. In standard construction, the distance from subgrade to base of rail is 15 ins.; the minimum depth of ballast allowed under the ties is 4 ins., while the standard depth is 8 ins., and on curves the subgrade must be sloped so as to preserve these depths under the low rail on the inside of the curve. The life of the track structure varies with the different tunnels. The rails in some of the tunnels deteriorate rapidly on account of corrosion due to sulphur water, and in these places usually last about three years, or about half the life of rails in the open. Angle bars, however, must frequently be renewed twice during the life of the rail. Recently the rails have been painted before laying them in the tunnels, in order to prevent this corrosion, but we are informed that it is not yet evident that this has prolonged the life to any marked extent. Ties last from 6 to 15 years in tunnels, depending entirely upon local conditions; those constantly

wet or constantly dry last longer than those subject to variable conditions of moisture.

Track maintenance in tunnels is found to be much more difficult and expensive than in the open, due largely to drainage conditions and inability to do the same amount of work; the movements of the men are materially slower and in certain conditions of the atmosphere under a heavy traffic the smoke is so dense that the men cannot work for some time after the passage of a train. The labor account is more than double in tunnels than on the same section of track in the open. Renewal of rails in tunnels presents difficulties not encountered in the open. After the rail has been removed from the track it is usually necessary to drag the rails in "strings" out of the tunnel before loading them. Renewal of ties is necessarily somewhat slower in view of lack of space, and in some cases it is necessary to remove the rails when ties are being removed. In double track tunnels this need not be done, however, in view of the fact that the ties can be pulled out over the other track and laid longitudinally in the center or side ditches until removed by work trains.

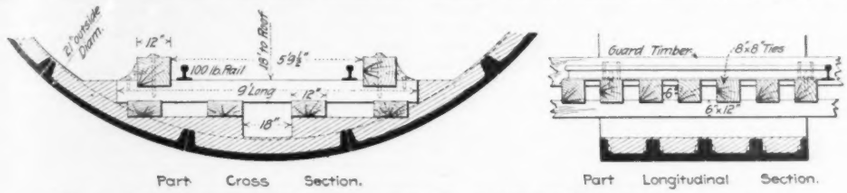


FIG. 2. TRACK CONSTRUCTION IN THE ST. CLAIR TUNNEL: GRAND TRUNK RY.

As to the protection of men working in tunnels, all tunnels are protected by signals at the entrance (using either automatic signals or the train-staff system) so that when any work is being done that affects the safety of trains the signals are used to hold trains until the track is safe. In addition to this, flagmen are stationed at each end of the tunnel while work is in progress. The number of trains passing through tunnels varies greatly, but the average daily movement of the different tunnels is from 50 to 140 trains daily.

SOUTHERN PACIFIC.—Of this system (including the Union Pacific Ry. and the Oregon Short Line) the ordinary track construction is employed, except in regard to the ballast arrangement. The following information has been received from Mr. Wm. Ashton, Chief Engineer:

Through short, dry tunnels the ordinary track construction has proved efficient. Through wet tunnels in soft material ordinary track construction, so far as rail, ties and fittings are concerned, is used, but the roadbed through the tunnel receives such treatment as would seem likely to give this roadbed the necessary permanency. That is, in some of our tunnels concrete drains are provided as a part of the concrete lining of the tunnel; in others cement pipe extends along both sides of the track at such a depth as would seem proper to give the roadbed good drainage. In some cases crushed rock ballast is put in with a view to giving the best possible drainage to the tile drains placed underneath and outside the track. We have put in no track that might be termed experimental. We have, in all cases, used the ordinary construction except as to ballast.

In wet tunnels the maintenance of track is as a rule more expensive than track maintenance outside of tunnels. In none of our tunnels have we noticed corrosion of the rail that would cut any figure in the maintenance expense. While in most of our tunnels the rail corrodes somewhat faster than it corrodes outside, as a rule the rail wears out from traffic before the corrosion in any way impairs its suitability for traffic. As to handling long rails, the longest rail we use is 33 ft., and we have no difficulty in handling rails of this length in our tunnels. The handling and placing of ties is much more expensive than the handling of ties in the open. Some of our trackmen estimate that the renewal of ties in tunnels averages at least double the cost of these renewals in the open. The lack of light and the lack of width for removing the old tie and replacing it with the new tie are, of course, important features in this added expense.

All of our tunnels are provided with automatic electric signals and advantage is taken of these in doing such work in the tunnels as cannot be promptly cleared for trains. The Soutern Pacific Ry. tunnels have ample width for clearing trackmen with ordinary tools. In the narrow tunnels refuge caves are provided large enough for a good size track gang or even a hand car. Our record of accidents at tunnels would indicate little if any more danger in maintenance of track in tunnels than elsewhere, although, of course, the mileage of tunnels is so small that a fair comparison can hardly be made. Men and trains are protected by automatic electric signals when track work is being done in tunnels. They are also protected by the ordinary signals used in connection with track work. The regular track gangs do all the track maintenance and repairs. Through all the tunnels considered in this communication the number of trains would average between 8 and 15 trains per day each way, or 16 to 30 trains per 24 hours through the tunnels. Our longest tunnel is the Aspen tunnel on the Union Pacific Ry., 5,900 ft. in length.

In my experience, the increased cost of maintenance of track in tunnels is almost exclusively in the maintenance of roadbed; that is, keeping the track in line and surface, with the increased cost of replacing ties and rail. Where rail is changed but once in ten years or some such period this increased cost is not an item of great importance, and in every case it has been my experience that the rail would wear substantially as long in tunnels as in the open and that the corrosion in no case amounted to enough to influence the life of the rail.

The track construction in the Aspen Tunnel is shown in Fig. 1, for both flat floor and concrete invert, but in some tunnels with rock bottom a 6-in. drain 18 ins. wide is cut at each side.

GRAND TRUNK.—Ordinary track construction is usually employed in tunnels, but a special construction is used in the long tubular iron-lined tunnel under the St. Clair River. This is shown in Fig. 2. The tunnel is 19 ft. 10 ins. inside diameter, with a height of 18 ft. above the ties, and below the center line it has a 6-in. filling of brick and cement between the flanges of the iron lining segments. A concrete floor is built upon the invert. The floor has a central drain and forms a bench for four longitudinal 12 × 6-in. timbers, upon which are laid 8 × 8-in. ties, 9 ft. long, boxed out over the longitudinals. The concrete is filled in against the outer longitudinals and the ends of the ties, so as to prevent any lateral movement. The ties are 6 ins. apart in the clear, and carry heavy guard timbers boxed out 2 ins. over the ties, so as to hold the latter in place. The rails weigh 100 lbs. per yd. and are 5¾ ins. high. This tunnel is to be converted from steam to electric traction, using an overhead conductor, and in order to increase the clearance it has been proposed to remove the ties and lay the rails on longitudinals; this change, however, has not been definitely decided upon.

ENGLISH RAILWAYS.

GREAT CENTRAL (C. A. Rowlandson, Chief Engineer).—The track construction in tunnels is similar to that in the open, except that a rather heavier section of rail is used. Rails corrode more quickly in tunnels than in the open; there is also greater expense in maintenance, owing to a greater number of men being required on account of the difficulty in carrying out the work under the unfavorable conditions resulting from darkness, smoke and steam.

GREAT NORTEHRN (A. Ross, Chief Engineer).—The track construction is the same both in tunnels and in the open. It consists of 100-lb. bull-head rails of the British Standards section, in 45-ft. lengths, carried by cast-iron chairs weighing 57 lbs. at the suspended joints and 53 lbs. on the intermediate ties. Each chair is secured to the tie by two round wrought iron spikes and two trenails. The rails are secured in each chair by a teak key or block 7½ ins. long. The ties are of creosoted Baltic fir, 9 ft. long. The joint ties are 12 × 6 ins. and the intermediate ties 10 × 5 ins. There are 18 ties to a 45-ft. rail length. The rails are painted with either three coats of red lead and boiled oil, or two coats of "carbon tar" obtained from the manufacture of oil gas. This reduces the loss of weight of the rails by corrosion and so increases their life. For ordinary maintenance work, the repairs are made at night, when the traffic is comparatively light; this work is done by the regular section gangs. In the busiest tunnels on this line there are about 200 trains in 24 hours on each track.

GREAT WESTERN (G. C. Louth, Engineer of Permanent Way.)—No special track construction is used in tunnels, the only departure from the standard type being that 20 ties instead of 18 to a rail length are used in a few tunnels. This practice is followed in the tunnel under the Severn River, which is 4⅓ miles long, with grades of about 1% on each side. In this tunnel the rails are of the bull-head section, weighing 97½ lbs. per yd., and are in lengths of 44½ ft.; they are laid with square suspended joints, spliced by flat splice bars (inside 20 ins. and outside 18 ins. long) and four $^{15}/_{16}$-in. bolts. They are keyed in cast-iron chairs, weighing about 59 lbs. each, and each chair is secured to the tie (under hydraulic pressure) by two ⅞-in. bolts with nuts on top. The ties are 10 × 5 ins., 9 ft. long. The ballast is broken limestone, and is renewed in from four to seven years, according to its position in the tunnel. The cross-section in Fig. 3 shows the unusually large bed of ballast in the Severn Tunnel. This tunnel is 24 ft. wide at the rails and 26 ft. at the springing line of the arch, with a headway of 20 ft., and a depth of 4½ ft. from head of rail to invert. On the invert is a semicircular brick drain or culvert about 4 ft. in diameter, over which rough stone bottom ballast is filled. The ties are embedded in about 15 ins. of ordinary ballast. The minimum depth of ballast under the ends of the ties is about 9 ins. There is no trouble as to drainage, temperature or noise, but although the ventilation is assisted by a fan, an improvement of the means of ventilation is now being considered. The drainage is pumped from a bottom heading by a pumping station on one bank. The heaviest locomotives used in this tunnel are 75½-ton tank engines carried on ten wheels. There are about 60 to 70 trains each way per 24 hours.

LANCASHIRE & YORKSHIRE (D. C. Rattray, Chief Engineer).—No special track construction is used in tunnels, and no difficulty is experienced in maintaining the track in tunnels. The rails are protected, however, against corrosion, being painted with a mixture of red lead and linseed oil put on hot before the rails are laid.

MIDLAND (W. B. Worthington, Engineer-in-Chief).—The track construction in tunnels is the same as in the open. No experiments have been made with special construction. The rails are of the bull-head section, 100 lbs. per yd., in lengths of 36 ft. They are supported by 54-lb. cast iron chairs, and laid with suspended joints spliced with 20-in. flat splice bars and four bolts. The ties are of creosoted Baltic red fir 9 ft. long, and 10 × 5 ins. in section. There are 14 ties to a rail length, spaced 26¼ ins. c. to c. at the joints, and 29⅛ ins. intermediate. The wear of rails is very much more rapid in tunnels than in the open, owing largely to the effects of corrosion. To check this, it is the practice to give the rails three coats of red-lead paint

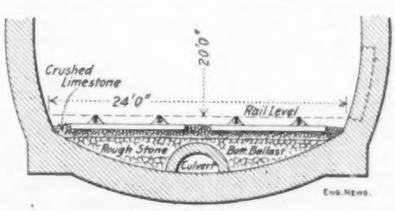


Fig. 3. Track Construction in the Severn Tunnel: Great Western Ry. (England).

before they are taken into the tunnel, and this has undoubtedly had the result of increasing their life. Track laying in tunnels is done on Sundays, when possession of the line can be obtained, and is done by special gangs. The protection of this work is provided for in the standard rules, and in some of the larger tunnels telephones are provided so that the men at work can communicate with the signalmen in the block signal cabins at each end. The trains in some of the busy tunnels number from 103 to 146 on each track, or from 207 to 282 in both directions per day of 24 hours.

NORTH BRITISH (James Bell, Chief Engineer).—The track construction is the same in tunnels as in the open, and there is not found to be any special difficulty or expense in regard to track maintenance in tunnels. Where the traffic is heavy, the maintenance and repair work is done at night, while the traffic is light. The work is done by the regular gangs, and the usual precautions for their protection are taken by displaying flags or lamps and placing torpedoes on the rails. On the Glasgow City & District underground line there are about 140 trains on each track during week days and 150 trains on Sundays. In other tunnels there are from 85 to 120 trains on each track per day.

EFFECT OF THE SAN FRANCISCO EARTHQUAKE ON SEWERS AND PAVEMENTS.

Through the kindness of the parties concerned we are enabled to present herewith a letter on the effect of the earthquake of April 18, 1906, on the sewers of San Francisco. The letter was written by Mr. Harris D. Connick, of San Francisco, to an engineer in another city. Mr. Connick had charge, under Mr. T. P. Woodward, City Engineer of San Francisco, of sewer and street improvements being carried out at the time of the earthquake. The letter is as follows:

For convenience, I will divide the area of San Francisco into four classes and describe the effect of the earthquake on the sewers located in each division.

(1) Rock; (2) rock overlaid with sand; (3) filled-in tidal areas, the bottoms of which are soft mud of considerable depth; (4) filled marsh land and swamps which were originally about the same elevation as ordinary high tide.

In ground of the first class, there has been no permanent displacement noted, and the sewers were not affected.

In ground of the second class, there was no permanent displacement except where the original ground supported a fill. The vicinity of the crossing of Van Ness Ave. and Vallejo St.* illustrates a case of this type. The street profiles show that the original ground was about 25 ft. below the present surface. The fill, it is claimed, was made of sand and has been in place all of 20 years. The streets are all paved and the property covered with residences. The maximum settlement due to the earthquake was 2.4 ft.; the lateral movement, 3.5 ft. The sewers in the area that settled were destroyed.

In ground of the third and fourth classes, there was considerable movement in a number of places, the most being in the vicinity of Valencia St., between 16th and 17th Sts., where the lateral displacement was 6 ft. in an easterly direction or towards the Bay, and the settlement about 5 ft.

Where there was no permanent movement in the ground the sewers were not injured to any marked extent, but where the ground moved, as it did at Vallejo St. and Van Ness Ave. and Valencia St. between 16th and 17th Sts., the sewers were destroyed. All of the masonry sewers injured with one exception were constructed a number of years ago, of brick laid in a poor quality of lime mortar. Where there was much lateral movement they failed by collapsing; where the movement was vertical, they failed along planes perpendicular to their axes. Where the iron-stone pipe sewers were located on firm ground there are no evidences of failure, but where they were constructed on streets in which there was a permanent movement they will have to be reconstructed.

At the time of the earthquake there were a number of sewers being constructed under the bond issue. The masonry sewers were, with one exception (the Baker St. sewer), located on firm ground or supported on piles and not injured. Along Baker St. there was being constructed a 5-ft. circular sewer of concrete, with the crown and haunches reinforced with No. 2½ mesh No. 16 gage expanded metal. Because of certain local prejudices, it was necessary to design this sewer with an unusually heavy section. The foundation of the finished portion of the work was sand over-lying mud, and a portion was supported by piles. The ground settled unevenly along the line of the sewer, there being little or no lateral movement. This ground movement caused the sewers to fail by breaking open along planes perpendicular to their axes. Most of the breaks occurred at the joints formed between each day's work. There were no cracks along the line of the sewer.

In this city a reinforced concrete sewer, on a pile foundation where the ground does not furnish suitable support, will probably give the best satisfaction. It should be designed with rather a heavy cross-section and the reinforcement should be sufficient and so placed that even if the sewer should be broken by an earthquake the steel will hold the separate pieces of concrete in place so that it will not go out of immediate service, as the brick sewers did. One should also not forget that with the exception of the Baker St. sewer the masonry sewers that failed were very poorly constructed of brick; in fact, in many of our old sewers there is nothing but sand in the joints of the brickwork, and they are held up almost entirely by the pressure of the earth. Had they been well constructed of brick laid in Portland cement mortar and on a pile support where necessary, they would not have fared so badly.

I believe that $100,000 will cover the total damage to the sewers by the earthquake.

In preparing the detail plans of our sewer system, the possibility of a change in the hydraulic grade lines of main sewers by a change in the vertical portion of the peninsula with regard to higher high tide will be considered.

In regard to the movement of the whole coast between Santa Rosa and San Jose: The area west of the fault has moved about 8 ft. north of the area to the east, and it has been stated that the whole west coast has raised. I have been informed that the U. S. Coast Survey has parties in the field at present testing the triangulation and rerunning their precise level lines to determine if there has been any general change in elevations.

The full effect of the damage done to curbs and pavements by the earthquake and fire will not be known, Mr. Connick states in a report to Woodward, until the debris has all been cleared away and instrumental surveys have been made. Some of the stone pavement and curb was badly spalled by the fire, and some asphalt pavement was more or less badly charred by the heat, and can be easily scraped off to a depth of ½ or ¾-in. in places. A chemical analysis will be necessary to determine the condition of the wearing surface under the charred material.

*Maps of San Francisco were published in Engineering News of April 26 and May 17, 1906.

MEETINGS OF THE NATIONAL IRRIGATION CONGRESS AND THE ASSOCIATION OF STATE ENGINEERS.

By Samuel H. Lea.*

The writer, as a delegate from the state of South Dakota, attended the Fourteenth National Irrigation Congress, held at Boise, Idaho, Sept. 3 to 7, 1906.

During a brief stop at Omaha evidences of much commercial activity were noted. A number of large and substantial business buildings are under construction.

A stop was made at Cheyenne to visit the State Engineer's office and observe methods and practice. Wyoming has had an irrigation code for a number of years and has consequently had the benefit of long experience in determining the most suitable methods of procedure in water rights and irrigation engineering.

Idaho was entered early in the morning and for almost the whole day nothing could be seen from the car window but dreary stretches of sagebrush covered plains. At American Falls the Snake River was crossed, and thereafter the valley of this river was followed for some distance. An interesting sight along this stream is the number of water-wheels in use for lifting water for irrigation. At each place where a wheel was in use, flourishing green fields were seen, veritable oases in the desert and affording good evidence of the benefits of irrigation.

Boise, the meeting place of the Irrigation Congress, is a prosperous city of about 15,000 population, with many evidences of substantial progress.

IRRIGATION CONGRESS.—The Congress was called to order on the morning of Sept. 3 and daily sessions were held until the evening of Sept. 6. This Congress was the most successful of any yet held. Many interesting papers were read and some animated discussions were had on subjects of more than usual interest.

The governors of several states of the northwest were present and made addresses, and many of the engineers of the U. S. Reclamation Service were in evidence. The widespread interest taken in the subject of irrigation is shown by the attendance at this Congress of 1,215 delegates from 30 states, including the territories of Arizona and New Mexico.

The fact was brought out during the Congress that several reclamation projects are being executed under the provisions of the so-called Carey Act by corporations working under the supervision of the state. One of the most important of these projects is that of the Twin Falls Land & Water Co., operating on the lower Snake River, in Idaho. Other similar projects are under way in Idaho and Montana.

A subject of much importance brought to the attention of the Congress was the question of the control of interstate streams that are not navigable. This same question is now before the U. S. Supreme Court in the celebrated case of Kansas vs. Colorado concerning the waters of the Arkansas River. It developed during the discussion that other interstate streams are the subject of controversy between citizens using water from the same stream, but living in different states. It was stated that water users in a crest state in some instances would divert practically all the water from a given stream, thus depriving water users on the stream in a lower state of water to which they were entitled by prior use.

It was decided to hold the next annual meeting of the National Irrigation Congress at Sacramento, Cal., at a time to be determined later by the executive committee.

STATE ENGINEERS.—A meeting of the Association of State Engineers was held in Boise during the Congress. There were present at this meeting the following engineers of the respective states named: T. W. Jaycox, Colorado; Jas Stephenson, Jr., Idaho; John W. Wade, Montana; C. Thurtell, Nevada; A. L. Fellows, North Dakota; J. H. Lewis, Oregon; Samuel H. Lea, South Dakota; Caleb Tanner, Utah. The subject of the proposed irrigation code of the state of Montana was discussed at the meeting and several amendments thereto were suggested.

Officers elected for the ensuing year are: President, James Stephenson, Jr., of Idaho; secretary, Clarence T. Johnston, of Wyoming. It was decided to hold the next meeting at Reno, Nev., April 8, 1907.

EXCURSION.—After the adjournment of the Congress such of the delegates as cared to go were taken on a trip of inspection to some of the newly irrigated districts of Idaho. This trip was made through the courtesy of the Oregon Short Line, which provided a train of 12 coaches, mostly Pullman sleepers, and carried 350 of the delegates without charge for two days through the irrigated country. The first day was devoted to the Twin City Project, previously referred to. A stop was made at the Milner dam on Snake River at the head of the main canal. The town of Twin Falls was next visited. This is about the middle of the tract and is a type of the new order of town building. It was laid out two years ago and now has a population of about 2,000, with several hotels, brick blocks, etc. From Twin Falls we were taken in vehicles to see Shoshone Falls on Snake River, about five miles away. The second day of the trip was spent on upper Snake River, beginning at St. Anthony and winding up at Idaho Falls. We were then brought to Pocatello, where the party disbanded.

CONCLUSIONS.—This Congress demonstrated to many the vast extent of country in the United States that is largely dependent upon irrigation for its settlement and development. It also demonstrated the widespread and deep interest taken in the subject of irrigation by all classes and conditions of people. The fact was brought out that there are some very complex and difficult problems to be solved before irrigation on a large scale is developed much more. Not the least important of the many important demonstrations to the delegates was the immense value of irrigation to arid land when properly applied.

*State Engineer of South Dakota, Pierre, S. Dak.

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The recent failure to sell the $500,000 bonds intended to raise money for carrying on the important work of the additional water supply for New York City will doubtless cause only a slight temporary embarrassment, if indeed it really hinders the development of the supply at all; but, nevertheless, the incident should teach some lessons. According to the legislative statute authorizing the bond issue, the bonds were limited to twenty years and could not be sold at less than par. The rate of interest offered by the city was 4%. Only one bid was received and that was for $100 worth of bonds, only. It is hard to see how a bond issue of this sort ever came to be restricted to a term of twenty years, particularly in view of the fact that a large portion of that time will be required for the mere construction of the works. The Croton Aqueduct Commission, it may be noted in passing, although it has been in existence more than twenty years, still has work laid out for several years to come. It would not be a bit surprising if the heavy and extensive construction work which will fall to the Commission on Additional Water Supply should extend over an even longer period, although it is, of course, expected that a large quantity of water will be delivered to the city within seven or eight years.

Although the failure of this particular bond issue was largely due to the general condition of the money market, as well as the short life of the proposed bonds, yet there are many who believe that the vast expenditures for public works now being incurred and proposed in New York City are materially lessening the attractiveness of New York bonds to brokers and investors. We are not inclined to give a great deal of weight to this theory, but the possibility of its validity should certainly be taken into consideration by the city authorities. It may yet be proven that before launching out on such extensive water-works improvements the city might better have spent a relatively small sum of money to put down and keep down water waste. We acknowledge that there is much force in the arguments which have been brought forward to the effect that the greatest practicable reduction in water waste would after all make very little difference in the size and cost of the works for additional supply. But New York and other cities should always bear in mind that as between providing a water supply sufficient for unrestricted and for carefully restricted waste there is a possibility of a considerable margin in capital outlay, and that if the more popular course of building works for a lavish supply is followed, a pinch may result later on, either in the development of the works in question or in the securing of necessary funds for other needed public works.

Finally, we may call more particular attention to the ridiculous condition in which the second largest city in the world finds itself, owing to its absolute dependence upon the State Legislature in the matter of such details as the life of bonds to be issued for municipal improvements. As the case in hand stands, there is nothing for the city of New York to do but wait until the next session of the Legislature before it can secure authority to make its water-supply bonds run for 30 or 40 instead of for the absurdly low period of 20 years.

Among the things that engineers have good reason to be thankful for is their relative freedom, as compared with architects, from the vexed problem of competitions. This subject has again been brought prominently before architects by an announcement of a competition designed to secure plans for a $4,000,000 educational building at Albany, N. Y. The main features of this competition are set forth in a typewritten statement sent out from Albany, as follows:

> Plans for the new Educational Building to be built by the State in Albany, N. Y., at a cost of $4,000,000, will be selected in the following manner: Two competitions among architects will be had. In the first competition, all architects will be invited to compete, and they will be given about three months' time to make their plans. Out of these plans presented to the board of award (composed of trustees of public buildings, of which Governor Frank W. Higgins is chairman; Dr. Andrew W. Draper, Commissioner of Education, and Dr. Albert Vander Veer, of the Regents), the ten best plans will be selected by the board. The board of award will call the authors of the ten best plans together to advise with them in regard to a second competition between the ten. In the second competition, the board will select the first, second and third most meritorious plans submitted and these three sets of designs will become the property of the state. The architect of the three, whose plans are considered best, will be employed as architect of the building, provided he is a man of assured responsibility.
>
> In the matter of awards, it is expected to pay each of the ten architects successful in the first competition $500, and an additional $1,000 if he goes into the second competition in good faith. Besides these awards, there will be paid an additional $1,000 to the architect submitting the third best set of plans in the second competition, an additional $2,000 to the architect submitting the second best set of plans, and the income from the construction to the successful architect whose plans shall be adopted. The compensation to the successful architect is 5% of the amount of the contracts which figure in the erection of the new building. Prospectuses for the architectural competition will be prepared and ready for distribution shortly.

As is usual in competitions of this general character, a considerable number of men are asked to give their services absolutely without compensation, and only inadequate compensation is offered for such as are paid anything. The object of the competition is to provide the state with a large variety of preliminary plans from which it can select. In the first of the proposed two competitions, the insignificant sum of $500 will be paid to each of the architects submitting one of "the ten best plans," and $1,000 additional for each or such of the ten as enter the second competition "in good faith." In the final competition, one of the ten will be paid $1,000 and another $2,000; the first best will receive the appointment and will be compensated for his work at the rate of 5% on the contract prices, in addition to the $1,500 which he would have previously received. Leaving out of account the 5% commission as applying to the work done by the fortunate architect subsequent to his appointment, the State of New York will at most have paid $18,000 for the benefit of what its representatives hope will be a large number of preliminary plans for a $4,000,000 building. If it followed out the accepted practice among the best architects, of paying 1½% for preliminary sketches, it would cost the state $60,000 for one man's preliminary plans alone.

Having discussed briefly the compensation feature of the competition, attention may be turned to what is in some respects a more serious aspect of the case, namely, the fact that all this unremunerated and poorly paid work asked for by the great State of New York is to be judged, so far as the announcement indicates, by three laymen, some if not all of whom owe their offices to the chances of politics. Such conditions, we should suppose, would keep most or all of the best architects out of the competition. It may be, however, that the conditions will be materially improved for the "ten best," as a result of the conference which it is proposed to hold between them and the board of award, when these ten men are selected.

The history of cable railways as a means of rapid transit for cities has been short but eventful, the rise and fall of the cable traction system covering little more than 30 years. Beginning in San Francisco in 1873, as stated elsewhere in this issue, the cable system was afterwards adopted in numerous other cities, both for steep-grade and level lines, and it had a great success until the development of the electric traction system. In most cities it has now disappeared or is rapidly disappearing, giving place to the electric system, even on steep-grade lines. In a review of the history of cable traction published in our issue of Nov. 7, 1891, it was shown that nearly 600 miles were then in operation in the United States, while nearly 100 miles more were under construction. But in an article on the comparative cost of cable and electric railways in our issue of Oct. 27, 1892, it was shown that the former system had even then practically reached the limit of its capacity for improvement. It had reached its greatest development by 1895, while at the present time it is practically obsolete. The recent abandonment of the system at Chicago calls attention to this fact. The Chicago system has been continued thus long only as a result of the long and bitter controversies and litigation between the city authorities and the railway companies in regard to franchise matters. During this period of several years the city has refused to allow the companies to introduce the trolley system on the streets having cable lines, for fear this might invest the companies with certain rights. On the other hand, the companies were partly unwilling (owing to the uncertain outlook for the future) and partly unable (owing to financial entanglements) to make improvements upon the cable lines and plant, so that the entire cable system has been allowed to get into very bad condition. The recent court decisions and the orders of the War Department for the lowering of the three street railway tunnels under the Chicago River (all used by cable lines) have cleared the situation materially, and already several cable lines have been converted to the trolley system, while it is expected that all the lines will have been converted by the end of the year, so that in Chicago the history of cable traction will have covered a period of just 20 years. In New York, Philadelphia, Cincinnati, and several other cities, cable traction has been a thing of the past for some years. In San Francisco it is still in somewhat extensive use, but the indications are that in the present reconstruction of the street railway system, electric traction will be introduced on several of the old cable lines. Cable traction was first introduced for rapid-transit service on steep grades, but it soon developed its advantages for level lines, and marked a new era in superseding animal traction on important lines. The cost of construction, however, made it unsuitable for suburban and feeder lines. The introduction of electric traction made an entire change in the situation. It was much less costly to install and operate, was equally well adapted to business, residence and suburban districts, and could be extended almost indefinitely where and when desired. Steep grade lines were at first considered to be still a field for the cable system, but it was found that the electric system could be safely operated on all but very severe grades, and could in fact be operated even on the severest grades when supplemented by a counterweight system. One point in favor of the electric system is its greater flexibility in the distribution of cars and the handling of traffic. The electric car can be handled at very high speed if necessary, but the cable car is limited to the regular speed of the cable. The cable railway was a great improvement over the horse railway, and

has a notable place in the history of rapid-transit, but it is now obsolete and has been superseded by the newer development of the electric railway.

There is a widespread opinion that engineers are not "practical" when it comes to the actual execution of work. That the engineer is a useful and necessary creature for making measurements and drawings is generally agreed. That his scientific knowledge enables him to make plans and offer advice as to how an engineering work should be constructed is also conceded; but when it comes to actually doing the work—excavating, building or whatever it may be—there is well-nigh universal distrust of the engineer. It is generally felt that he is not a "practical" man. Of course, he could manage to carry out the work, and very likely it would be of high quality when completed, but its cost would be enormously greater than if done by contract in the usual way, and it would doubtless be an interminable time in construction, for the engineer is not supposed to be a "hustler" like the contractor.

We do not think the above statement in any way exaggerates the estimate of the engineering profession which the general public holds, and we may add that such views are sometimes heard expressed even inside the profession.

In contrast with this view of the engineer we wish to place the record of an actual achievement by engineers on the work of creating the new 40-ft. channel entrance to New York Harbor. This work was let over seven years ago to a contractor of wide experience, high reputation, and ample financial backing. He agreed to complete it in six years, with heavy penalties for delay in the prosecution. The work is entirely deep-water dredging, and his contract price was 9 cts. per cubic yard. The required rate of working was never maintained or even approached, and three years ago Congress provided funds whereby the Government's own engineers could attack the work side by side with the contractor.

We print in this issue the record of what these engineers have actually accomplished. The two dredges built to their designs, manned by their own employees and operated under their direction have actually in the past year moved nearly three cubic yards of material while the contractors two dredges were moving two cubic yards, and the cost of this day-labor work per cubic yard moved is actually much below the price which the Government is paying to the contractor; and which, it has been widely claimed, was insufficient to leave him a fair profit.

We believe this record of achievement in "practical" work deserves recognition by the public, and particularly by the engineering profession. It is unfortunately common to hear the work of the Government engineers on River and Harbor Work spoken of in just the manner we have outlined above. Many in the engineering profession do not credit the Corps of Engineers and its civilian staff with the ability either to "hustle" work or to do work cheaply. What grounds there may be for this opinion we need not here discuss; but the notable record made by the force in the U. S. Engineer office at New York City on the Ambrose Channel certainly deserves the applause of their professional brethren.

As to the reasons for this excellent record, we cannot do better than quote from Assistant Engineer Babcock's official report:

> We are accomplishing more work and better work with a smaller and less costly plant than the contractor's; but it would not be fair to ascribe the difference in result altogether to difference in kind of plant. We have a better management, system and personnel, from the Chief of Engineers and yourself down to the deckhands and sailors; the plant is kept in better order and the work is done more harmoniously and industriously.

We commend this statement to those who have formed the opinion that Departmental red tape prevents our Government from carrying out work efficiently in any other way than by contract.

It is well known among engineers engaged in works for river and harbor improvement that the great reduction in the cost of dredging which the hydraulic process has effected must be taken into account in deciding on methods and plans for any important work in this field. The actual cost of hydraulic dredging done on a large scale, however, varies so considerably with the conditions that accurate data of the cost of any such work are important and valuable to every engineer in any way interested in this class of work.

The paper by Mr. Henry N. Babcock, M. Am. Soc. C. E., above referred to, therefore, will be closely followed we are sure by a large class of our readers. Besides the data given as to the cost of the work and rate of progress, the paper records some practical experience in dredge design which cannot fail to advance the art.

Of course hydraulic dredging where the material is discharged into bins and carried to a dumping ground can never reach the enormous output or very low cost of work done by dredges delivering through pipes. The surprising thing about the Ambrose Channel work, however, is that it approaches so nearly to the ordinary records of work done with the latter class of dredges. The Government's two dredges on Ambrose Channel in a single month have actually excavated and carried eight miles out to sea 535,692 cu. yds. of material. During the 11 months ending May 31 last, the total operating cost of these two dredges was only 5.274 cts. per cu. yd.

TRACK CONSTRUCTION AND MAINTENANCE IN RAILWAY TUNNELS.

The peculiar difficulties attending the work of track maintenance and renewal in tunnels, with the attendant danger and expense involved, make this a good field for investigation with a view to the introduction of a more permanent type of track construction which will not require so much attention. The reduced life of rails in tunnels, due to corrosion and other influences, makes the matter of still greater importance. The difficulties, of course, vary with the conditions existing at each tunnel: in short, dry, well-ventilated tunnels, of large dimensions and with a moderate number of trains, these difficulties will be reduced to a minimum. On the other hand, they will be at a maximum in long tunnels of small dimensions, where dampness aids corrosion, and where smoke and gas make it almost impossible for men to work until some time after a train has passed, or where frequent trains allow little time for continued work. The varying combinations of these several conditions in different tunnels will, of course, determine the character of the difficulties to be encountered. The subject of track construction in underground railways for rapid transit service, operated by electric traction, was discussed in our issue of Aug. 2, 1906; we are now dealing only with ordinary tunnels on steam railways.

In tunnels, the work of maintenance is somewhat different from that in the open, and where conditions are unfavorable and traffic is heavy the work of renewing rails, ties, etc., is not only difficult and dangerous, but tedious and expensive. Accordingly it may often be economy to make a somewhat larger expenditure upon a substantial and permanent track construction in order to reduce the future work of maintenance. It is, of course, generally desirable to have a uniform type of track, but at the same time this uniformity may well be departed from if special construction will produce material advantages. As a general proposition, it may fairly be said that on roads having numerous tunnels or heavy traffic through important tunnels (as near large cities), the track may with advantage be of special design.

In regard to construction, it must be borne in mind that the roadbed in tunnels is largely free from the disturbing influences of frost, rain and wind (causing either heaving or settlement); in general there will be either a hard rock bottom or a masonry invert, forming a solid and permanent base. Ballast, therefore, is required not for the purpose of leveling up inequalities of surface or providing against settlement and heaving, but only as a cushion bed for the ties; and in some cases the permissible depth of ballast under the ties in tunnels is so small that its value in this respect is questionable. It is generally held that such a cushion is absolutely necessary, but there are indications that such is not the case, as was suggested in our issue of Aug. 2, in the article already noted. The experience with electric railway track having girder rails on concrete foundations points to the adaptability of such a system for steam railways, but so far there has been little or no experience in this latter service. It has been claimed that the wear of heavy rails on a concrete base, due to a frequent service of comparatively light cars, is relatively greater than that of lighter rails on ties and ballast when carrying heavy steam trains. We have never seen any figures as to this, and the statement is probably based mainly upon general opinion.

Even if we grant this, however, we are not necessarily confined to the use of ballast. It may easily be the case that a timber bearing or a layer of felt or other elastic material will afford ample elasticity to prevent wear or noise due to a rigid bearing for the rail. It is certainly of sufficient importance to be worth trying on a scale that would produce definite results. If the ballast afforded a permanent support and maintained the track in permanent position it might be continued without objection, but this is not the case. The wear and vibration under traffic cause the ballast to settle unevenly, so the track must periodically be lined and surfaced. But in many tunnels the clearance for modern cars is very small, and as it is not easy (even on the open track) to make small adjustments in level by tamping, great care is necessary to ensure that the general level of the track is not raised so as to reduce the clearance to a dangerous extent. This is especially the case in adjusting the superelevation on curves in tunnels. It is generally considered that in stone, slag or coarse gravel, a thorough tamping can rarely be made without raising the track about 1 in., and some roads forbid the raising of track in tunnels or under structures where the headway is less than 22 ft. Furthermore, in many of the older tunnels only a very thin bed of ballast can be laid under the ties, owing to the necessity of maintaining headway for large cars. The value of such a thin cushion bearing is decidedly open to question, and the possible advantages of some different form of track construction become worthy of serious consideration. It is true that the floor of the tunnel may be lowered, and this is sometimes done; but it is a costly operation, and does not materially affect the track maintenance work.

The rapid corrosion of rails due to the effects of dampness, smoke and gases is probably experienced in a majority of tunnels, and is sometimes very severe; in many cases it may be reduced by proper ventilation. In some cases, however, there appears to be an actual deterioration in the quality of the steel in tunnels. The actual causes and character of this corrosion and deterioration have never been thoroughly determined, although the matter has been investigated to some extent. In a paper presented before the British Institution of Civil Engineers in 1900, Mr. T. Andrews cited the case of a tunnel where the average loss in weight due to corrosion and wear was 2.8 lbs. per yd. per year, as compared with 0.324 lb. per yd. for similar rails carrying similar traffic in the open. In England a very general practice is to paint the rails intended for tunnels, as reported in another column; this has been tried in some cases in this country, but the results do not appear to have been of particular value. The corrosion of spike heads, bolts and splice bars must also be considered.

The ties, in some cases, decay and wear more rapidly in tunnels than in the open, especially if the tunnels are damp. Concrete ties might be used to avoid this trouble, or even steel ties, if thoroughly protected against corrosion. Steel ties were at one time used in the great Got-

hard Tunnel (Switzerland), but were replaced with wooden ties. To avoid decay and wear it was at one time proposed to use steel ties in the Park Ave. tunnel approaching the Grand Central Station in New York City, and we quote the following from a report on steel ties issued by the United States Department of Agriculture (Forestry Bureau) in 1894:

After the successful results in point of maintenance which attended the use of the 800 Hartford ties laid in November, 1889, it was decided to use steel ties on the four-track line forming the approach to the Grand Central Station in New York, including the Harlem tunnel. On this line, over which run the trains of all the railways having access to the terminal station, there is an enormous traffic of regular trains, as well as of empty trains and light engines running between the station and the yards and the roundhouses at Mott Haven, the total number of train movements (including regular and empty trains, engines, etc.) being about 500 per 24 hours, and about three-fourths of this traffic is during the day hours. There is, consequently, much difficulty and waste of time (involving considerable expense) in effecting maintenance work and renewals to track, especially in the tunnel, without interfering with the traffic, and one of the principal reasons for adopting steel ties was to secure a permanent and substantial track, and thus effect a decided economy in the amount and cost of track work, both for labor and material. The track consists of 100-lb. rails with three-tie supported joints spliced by 36-in. angle bars and six bolts, and these are now laid on wooden ties in broken stone ballast.

Coming now to the question of maintenance of way in tunnels, it is general experience that this is more difficult, and consequently more costly, than in the open. In the first place the darkness is a serious difficulty. Men cannot see to make their inspections or to do their work to advantage by the light of common lamps or flaring torch lights. Smoke and steam not only delay the work by obstructing the sight, but, with the gases discharged from the engines, sometimes make it impossible for men to enter the tunnel until the atmosphere has cleared. All these difficulties mean loss of time, and are accentuated by dripping water, the confined space for work and the general discomfort. Again, when a train approaches, the men cannot simply step aside to let it pass as in the open; they must not only get off the track but must also see that everything is clear of the rails and cars, and perhaps take time to find the refuges or recesses in the walls. In tunnels with heavy traffic the maintenance work is specially difficult, and the men cannot work to advantage, as they have to be continually getting on and off the track and laying aside and gathering up tools, so that a considerable proportion of their time is thus spent in preparing for work and temporarily quitting work. Bolts and spikes are not removed as quickly or easily in tunnels as in the open, and are more liab'e to be lost; nor can the men handle and place the rails so easily. Tie renewals are still more difficult, as owing to the narrow space (even in double track tunnels) it is hard to get them from under the rails. It is sometimes considered best to remove the rails. Sometimes the ballast is removed between the ties to enable them to be slewed sideways, or it may be dug out under one end of the tie, so that when it is pulled out against the tunnel wall the inner end can be raised over the opposite rail. The placing of the new ties is equally difficult, and the distribution of new ties and collection of the old ties and their removal from the tunnel are also more or less difficult. In adjusting the level and the surface of the track after work of this kind special difficulties are encountered. The men cannot well see the effects of the blows of their tamping picks or bars, and the foreman has difficulty in sighting the rails or level boards. About 150 to 200 ft. of the track should be lighted up continuously for this work. The liability of reducing the clearance or headway in work upon the ballast has already been mentioned, and measurements should be taken from the rails to the roof at different points. Owing to these difficulties it is sometimes considered advisable not to attempt to make piecemeal renewals each year, but to renew all ties in a tunnel every few years.

Track work in the open is usually sufficiently protected by flags, but special precautions need to be taken for work in tunnels, to ensure the protection of trains as well as of the section men. Foremen should be particularly careful in such cases, and should display "slow" or "caution" signals if they are doing any heavy work. Where the block system is in force arrangements may be made by which signals will automatically operate a visual or audible signal in the tunnel to warn men of the apporach of trains. In England, where the manual block system is used, this warning is sometimes given by the signalmen nearest the ends of the tunnels. Where no block signals are used, the warning signal may be operated automatically by means of a track connection, or by the flagman.

Enough has been said to show that maintenance work in tunnels is as a rule difficult and dangerous, and consequently costly. It is reasonable to consider suggestions for improvements, and it may be said at once, without regard to any particular design, that a more permanent construction which will require less work for maintenance, will be advantageous, and may be a decided economy, even if of higher first cost. The most obvious suggestion is a concrete base or a pair of concrete longitudinals, built upon the floor or invert of the tunnel, and having the rails bolted directly to the concrete, or with some material interposed to impart a certain amount of elasticity. It may be said, however, that what is wanted is not an absolute elasticity of the track, but simply provision for absorbing the vibrations set up in the rail. In fact, some years ago, a French engineer proposed the construction of the invert or floor masonry with benches to carry longitudinal timbers for the rails, thus decreasing the height and cost of the tunnel, eliminating the ballast and ties, and reducing the work and expense of track maintenance in tunnels. Up to the present time the only practical application of this idea has been in the St. Clair tunnel of the Grand Trunk Ry.; this (as described elsewhere) has rails laid on closely spaced cross ties resting upon longitudinal timbers on the concrete floor. Special methods of track construction are being considered, however, for the new Detroit River tunnel and the terminal tunnels of the New York Central Ry. and Pennsylvania R. R. at New York.

LETTERS TO THE EDITOR.

How the Country Surveyor May Silence the Impertinently Curious.

Sir: In regard to the plaint of T. A. H., in your issue of Sept. 6, I would like to say that I have never had the trouble he seems to have. The Southern native is just as inquisitive a mortal as his New England cousin, I have no doubt, but I must say he evidently differs from him in politeness. A statement on the part of the surveyor or engineer that the work is of a private nature and your clients do not desire their plans made public is sufficient answer to all inquiries. Sometimes, however, an intimate acquaintance goes further, but an extravagant and ridiculous (incorrect, of course) answer given in the proper tone of voice disposes of him. I think if T. A. H. were to try this method he would achieve some success, and incidently find he had a growing reputation for discretion, which is no invaluable asset for a surveyor.

W. D. Sell.

Charleston, Kanawha Co., W. Va., Sept. 10, 1906.

Protection Against Loss from Long Overhaul.

Sir: The answer to the communication in regard to overhaul, by a contractor, in your issue of Aug. 30, would seem obvious.

Contractors, in bidding, should name such a price per 100 ft. of overhaul that they can afford to make the necessary haul, to balance the cost per cubic yard of borrow, within reasonable limits for hauling, with the equipment they propose to use on the work. In other words, instead of bidding 1 ct. per yd. of overhaul, at which rate they may be required to haul from 2,500 to 3,000 ft., why not bid higher on the item of overhaul—say 2 or 3 cts. per yard? That would harmonize with the prevailing prices for earth excavation and would probably not require them to haul more than 1,200 or 1,500 ft. Many contractors think that even this is too long a haul for ordinary grading, with slip and wheelers, and frequently come to the engineer for permission to "borrow and waste" before having hauled to the "economic limit." The remedy apparently lies with the contractor. Why should the engineer be placed in the position of apparently working a hardship when it is only a plain case of living up to the terms of the contract?

Construction Engineer.

Portland, Ore., Sept. 5, 1906.

A Further Note on the Analysis of Reinforced-Concrete Columns.

Sir: Referring to your comment on my suggested explanation of the lack of rigidity in a reinforced concrete column, in Engineering News of Sept. 6, I beg to suggest further that the concrete is not in all respects like a spring, but is restrained in the neighborhood of the steel more than at other points. Suppose, for example, that a column of concrete with a central longitudinal rod be molded. In setting, the concrete will tend to shrink, and near the outer edge of the column this shrinkage will actually occur, in practically full amount. But near the steel the shrinkage will be counteracted by the resistance of the steel to compression, and only a small part of the normal shrinkage will take place, resulting in longitudinal tension in this zone of concrete, and longitudinal compression in the steel. The end faces of the column will, therefore, not be planes, but will be low at the periphery, while the end face of the steel rod will be the highest point. Hence, when the column is put in the testing machine for a compression test, the load on the end blocks will be received by the steel and the immediately surrounding concrete before the concrete away from the steel receives its load. The concrete near the steel would therefore be under greater unit stress, and the apparent rigidity might be less than plain concrete. The case of a spring was cited to show that it is not necessary to assume that fissures exist where the concrete is not shrunk down to its normal size.

Yours very truly,

Edward Godfrey.

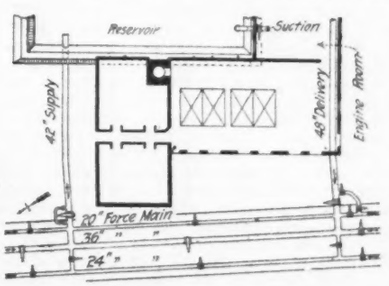
Pittsburg, Pa., Sept. 7, 1906.

RELAY PUMPING STATION FOR THE HACKENSACK WATER CO.*

By D. W. French.†

The Hackensack Water Co. is a private corporation organized and existing under the laws of the state of New Jersey, and operating in the territory located between the Hudson and Passaic rivers, north from Jersey City. The company commenced doing business in 1882, by supplying water to the city of Hoboken, N. J., which at that time was its only customer. At the present time supply is furnished to 41 towns and boroughs, including two cities, varying in population from about 1,000 to 65,000, and with a daily consumption of 20,000,000 gals., 90% of which is metered.

The entire system is a pumping system with the main station located at New Milford, N. J., at elevation 10 ft. above mean high water, and two distributing reservoirs



Arrangement of Force Mains and Valves at the Relay Pumping Station of the Hackensack Water Co., New Durham, N. J.

located at Weehawken, N. J., practically 15 miles south from New Milford, at elevations of 180 and 194 ft.

The pumping station and reservoir are united by three mains, a 20-in., a 24-in. and a compound main of 30 and 36 ins., each of which is laid over different routes, and from which many of the small towns obtain direct supply. About ten miles south from New Milford, at a junction called Ridgefield, the three mains meet and practically parallel each other along a public highway south to the Weehawken reservoirs. The capacity of the three mains referred to when running at a water pressure at New Milford of 120 lbs. per sq. in., which corresponds to a velocity in the mains of 3 ft. per sec., is 20,000,000 gals.

In the summer of 1903 our daily consumption steadily exceeded 17,000,000 gals. Knowing the route over which a new 42 or 48-in. main would be laid, and that to obtain 85,000 ft. of such pipe and lay it would require the best

*Condensed from a paper read before the American Water-Works Association, July, 1906.

†Superintendent, Hackensack Water Co., Hoboken, N. J.

part of two years, it was quite evident that some steps should be taken to increase the supply to the reservoirs without much delay. The disposition of our board of directors was to lay a 42-in. main from New Milford to the Weehawken reservoirs, the capacity of which being practically 19,000,000 gals. per day, would have about doubled our main carrying capacity, as well as furnishing an additional feeder to different parts of our territory. The three mains referred to are laid over elevations varying from 5 to 185 ft., the latter figure being the elevation at the extreme south end of the force main system. About five miles south of New Milford an elevation of 153 ft. was met, and after passing this point the mains are at an average elevation of practically 40 ft., and at New Durham, which is 10,000 ft. north from the Weehawken reservoirs, the elevation is 7 ft.

It had ocurred to the author of this paper that a relay pumping station could be switched into the force main system at New Durham, by doing which water could be drawn off from the three mains into a reservoir also located at a low level, and at a rate which would perhaps double the velocity in the mains.

If this theory were practicable it seemed possible to double our capacity at a point within two miles of the Weehawken reservoirs, and then by pumping the water back again into the same mains from which it was drawn, except against the opposite side of closed valves and through a short leg of the force main system, we figured that we could easily double the capacity through the two miles of mains, by getting rid of a tremendous loss of head due to friction. In other words, the capacity of the three mains from New Milford to New Durham, each about 70,000 ft. long, would be the same practically as the capacity of the same mains from New Durham to the Weehawken reservoirs, each about 10,000 ft. long. (See sketch, showing valve system, etc.)

To obtain some reliable data that could be used for a sound argument, two 12-in. blow-off connections were made to the 36-in. main.

At the New Milford station a 12,000,000 and an 18,000,000-gal. engine were in daily use, and after completing all arrangements, and closing all by-pass connections between the 36-in. main and the two smaller ones, the 12-in. valves were slowly opened, which was followed by an immediate increase in speed of the engines at New Milford. After the 12-in. valves were full open and enough time had elapsed for the engines to become steady, we found the delivery to be at the rate of 26,000,000 gals. per day, against a water pressure of 108 lbs., and through the large main alone, as compared with practically 20,000,000 gals. against a water pressure of 120 lbs., with all three mains in service. This rate of delivery would have been considerably greater had we been able to hold our steam pressure up sufficiently to have maintained 120 lbs. water pressure.

After this test was made it was a simple matter to estimate the quantity of water that could be drawn with the three mains in use, and maintain a water pressure at New Milford from 115 to 120 lbs. A report was made to the board of directors that the present mains without laying any additional pipe could be depended upon to furnish a supply until such a time as the total daily consumption approached 40,000,000 gals. At the same time it was recommended that means be taken to handle the water a second time at New Durham. This recommendation was immediately adopted, and contracts were let for a reservoir and also for foundations and buildings for a complete plant to be equipped with 2,000 HP. of boilers, with economizers and superheaters; also a 12,000,000 and 20,000,000-gal. Allis-Chalmers vertical triple expansion pumping engine. The erection of the engines, boilers, etc., was practically completed in September, 1905, which was promptly followed by an attempt to test the quantity of water that could be delivered at New Durham and still supply the numerous towns and boroughs to the north. With all of our high-pressure boilers at New Milford under steam, and with a 10,000,000-gal. high duty Worthington, a 12,000,000-gal. and an 18,000,000-gal. Allis-Chalmers pump moving, it was found that the delivery was practically at the rate of 37,000,000 gals. per day, of which quantity 34,000,000 gals. were being drawn from the three mains at New Durham. As the volume mentioned is within 3,000,000 gals. of the original estimate, it seems certain to predict that the demand north from New Durham will equal, if not exceed, 3,000,000 gals. between the time test was made and when the total consumption of the territory supplied reaches 40,000,000 gals. per day.

The total cost of the New Durham plant, including land, reservoir, foundations, buildings and their complete equipment, was $423,000. If, instead of building this plant, a new main had been laid from New Milford to Weehawken, it would have required a 42-in. main to have increased the capacity of the system to the extent the New Durham plant has provided. The cost of a 42-in. main, 85,000 ft. long, including rights-of-way, land damages, crossing a river 1,200 ft. wide on a pile foundation, together with considerable rock excavation, is estimated at $1,063,000. While there is a difference between these figures of $640,000, this amount does not cover the total advantage in favor of the New Durham plant. Since 1883 the company has been operating a high service station at Weehawken, N. J., located at an elevation of practically 170 ft. Water was drawn from an adjoining reservoir at elevation 180 ft., and pumped to a high service reservoir at elevation 318 ft. The high service district of the Hackensack Water Co. is quite an important part of its system, and at the present time has over 90 miles of pipe, in sizes from 6 to 36 ins., and over 9,100 house and factory connections. The new Durham station is so arranged that water is distributed to both low service reservoirs at elevation 180 and 194 ft., as well as to the high service reservoir at elevation 318 ft., at the same time, through an independent system of mains and independent machinery, but by the same force of help. This enabled us to abandon the Weehawken high service station, and also to reduce the cost of operation at New Durham (due principally to a modern equipment) from $7,000 to $8,000 per annum, which, capitalized at 5%, would represent interest on a $150,000 expenditure.

TESTS OF THE EFFECT OF HEAT ON REINFORCED CONCRETE COLUMNS.

By H. B. MacFarland.*

It is the object of this paper to present to the public the details of some interesting and remarkable experiments which were recently made at the Chicago Laboratory of the National Fireproofing Co. To Mr. E. V. Johnson, Vice-President and Western Manager of the aforenamed company, is due the credit of conceiving these experiments and carrying out the details. The writer was asked, as a disinterested party, to conduct the heat treatment tests; on this account he will draw no conclusions but will merely make a simple statement of facts.

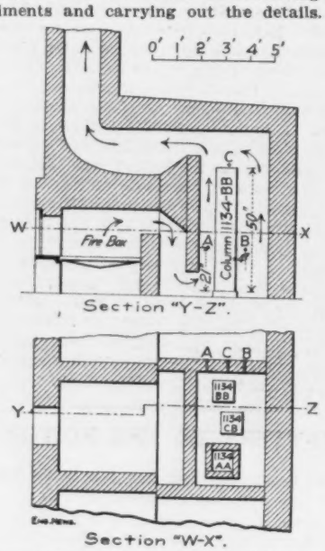


Fig. 1. Sectional Plan and Elevation of Furnace Used for Fire Tests of Reinforced-Concrete Columns.

A, B, C denote points where pyrometer was inserted.

The object of these tests was several-fold: First, to determine if a reinforced-concrete column when subjected to a temperature of from 1,500° to 1,600° F. for a period of three hours would be impaired in strength or elasticity; Second, to determine if possible the effect of quenching with water a concrete column which had been highly heated; Third, to show that a reinforced-concrete column encased in a fire-proof material is not impaired in strength or elasticity if subjected to a furnace temperature of 1,600° F. for several hours.

On Sept. 15, 1904, three reinforced-concrete columns were made. These columns were designated as Nos. 1,134-A, 1,134-B and 1,134-C, but later when they were cut into shorter lengths a second letter was added in order to preserve the identity of the specimen. The original dimensions of the columns were 10½ × 10¼ ins. by 12 ft.; the corners were rounded slightly, so that the columns had a cross-section area of 106.8 sq. ins. These columns were composed of a mixture of the following materials: One part of Portland cement (Owl brand), two parts of sand, of which one-half was torpedo and the other half bank sand, four parts of ¾-in. limestone. The reinforcement consisted of a ⅜-in. rod 2 ins. from each corner running the entire length of the columns.

When column No. 1,134-A was two months old it was subjected to a compression test and withstood a maximum total load of 77.5 tons; it gave way at one end. The column was left exposed to the weather, and in August, 1906, it was divided into two portions, designated as Nos. 1,134-AA and 1,134-AB, for further testing. The portion 1,134-AB was subjected to compression test on Aug. 14, 1906, and withstood a total load of 190 tons, that is, 3,558 lbs. per sq. in. The length of the specimen was 18 ins. The portion 1,134-AA, 6 ft. in length, was encased in solid porous tile, 3 ins. thick, set in cement, with metal fabric in the horizontal joints, and was reserved for a fire test.

When column 1,134-B was 3½ mos. old it was subjected to a compression test and withstood a maximum total load of 113 tons, or 2,116 lbs. per sq. in. The result shows that as compared with column 1,134-A, there resulted a 46% increase of ultimate strength in a period of 1½ mos. from the time after the column was two mos. old. After the column was tested it remained exposed to the weather until August, 1906, when a portion 5 ft. long was cut off and subjected to a fire test. This portion is designated as specimen No. 1,134-BB.

When column 1,134-C was 23 mos. old it was divided into two portions, designated as 1,134-CA and 1,134-CB. The portion 1,134-CB was reserved for fire treatment. The portion 1,134-CA was put in the testing machine and withstood a total maximum load of 137 tons, that is, 2,565 lbs. per sq. in. A photo of the specimen after test was taken as shown in Fig. 3.

Accepting the statement by noted authorities that there is no appreciable difference in the compressive strength of concrete columns centrally loaded of heights differing within ordinary limits, ranging, say, from 3 to 14 times the least lateral dimension, we may compare this result with those previously obtained from the 12-ft. columns. A comparison of results shows that in a period of 19½ mos. after the column was 3½ mos. old, there was a 21% increase in total strength, and in a period of 21 mos. after the column was 2 mos. old there was a 76% increase in total strength.

Since the height (18 ins.) of specimen 1134-AB is *not* at least three times as great as its lateral dimension of 10¼ ins., the compressive strength of this specimen cannot be taken as indicative of the strength of the long columns. It is a matter of interest, however, to note that this speci-

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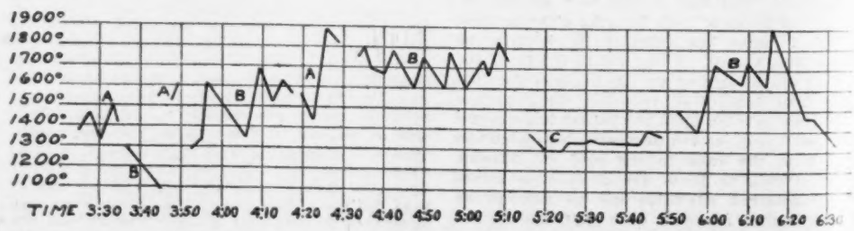

FIG. 2. CHART OF PYROMETER READINGS DURING HEAT EXPOSURE OF REINFORCED-CONCRETE COLUMNS.

men withstood a maximum load nearly 28% greater than specimen 1134-CA, although both were of the same age.

The results of all these tests show that all the columns were excessively strong, so far as compressive strength was concerned.

It was proposed that there be three specimens subjected to a fire test. One specimen was to be enclosed in a fireproof material, a second was to be subjected to the direct heat of the fire, and a third was to be quenched with water for a period of 5 mins. after the fire test had terminated. The temperature of the furnace was to be maintained as nearly as possible between 1,500° and 1,600° F., for a period of 3 hrs. After the fire test the specimens were to be put in the testing machine and subjected to maximum loads to determine the reduction, if any, of their compressive strengths, as compared with companion specimens previously tested.

The furnace, as shown in plan and section in Fig. 1, was exceptionally well built, of fireproof material. The heat was obtained from wood as a material for combustion which accounts for the rapid changes of flame temperatures, which occasionally amounted to as much as 150° within a minute. The distribution of the heat through the furnace and about the several columns was remarkably uniform. A sight-hole at the back of the furnace allowed one to observe the even distribution of the heat about the columns.

The temperature of the furnace was measured by means of a Bristol Electric Pyrometer. The element was inserted in various positions in the furnace from time to time; the positions have been designated in Fig. 1 as A, B and C. The position A was at the base and in front of column 1134-BB. The temperature here taken was that of the flame about 4 ins. in front of this column and about 21 ins. from its base. Position B was at the rear and at the base of the same column. The element measured the temperature 4 ins. in the rear and 21 ins. from the base of the column. Position C was on the top of the same concrete column. The element was placed so that it lay on the top of the column and indicated the temperature of the concrete column itself after the furnace had been fired for two hours.

The fire was started at 3:15 p. m. At 3:32 p. m. the flame temperature in position A was 1,500° F.; the heating was kept up for three hours after this time. The temperature was recorded at 1-min. or 2-min. intervals, as was deemed necessary. The results of this record are shown graphically in Fig. 2. The pyrometer was watched very carefully in order to direct the stoking of the fire, so that an excessive temperature might never be attained. At no time did the fire ever get beyond control; slight fluctuations of the temperature, however, were inevitable.

After the temperature of the furnace had remained above 1,500° for a period of three hours the fire was drawn and the side walls of the furnace were removed. Specimen 1134-BB was subjected to a water test for a period of 5 mins. Great care was exercised so that no water or steam came in contact with the other columns. City water was turned upon the specimen, but the water pressure was slight. When examined after the test visible cracks were noted extending lengthwise of the specimen and rendering it valueless as a column.

The specimens were allowed to cool slowly for 20 hrs., when they were removed to the testing room and the fireproofing material was taken off from specimen 1134-AA. Fig. 4 shows the appearance of this specimen after the fire test. It presented a sound appearance and when struck with a hammer it rang firm and clear. Fig. 5 shows the appearance of specimen 1134-CB after it had suffered the fire test and was set up in the testing machine. When tapped with a hammer it sounded dead and gave no resonance whatsoever. It had to be handled with extreme care to prevent it from crumbling away. Fig. 7 shows the condition of specimen 1134-BB after it had been subjected to both fire and water tests. When tapped with the hammer it sounded dead and disintegrated. When touched with the hand it shelled off as if it had been partially air-slaked lime.

These specimens were set upon a 340-ton hydraulic testing machine built by R. D. Wood & Co., of Philadelphia, Pa., and were submitted to compression tests.

SPECIMEN 1134-CB.—This column was 32 mos. old at the time of the test. On the day previous to testing it was submitted to a fire test, being exposed to a furnace temperature of from 1,500° to 1,600° F. for a period of three hours.

When the compression load was being applied it groaned and gave forth sounds indicating that its internal structure was being materially compressed. When the load was less than 5 tons the failure to hold indicated that its elastic limit had been passed. When the total load on the column was 10 tons and the column was tapped with the hammer it sounded fairly good. The column withstood a maximum load of 38 tons, or 711 lbs. per sq. in.

Fig. 6 shows the condition of the column when withstanding the maximum load. When crushed to destruction, there was no indication whatsoever of a bond between the concrete and the reinforcement. Any portion of the column could be crushed and ground up in one's fingers. When the load was 25 tons the column had decreased 7-16-in. in length. On comparison of the compressive strength of this column with its companion 1134-CA, which withstood a load of 137 tons, we find that the decrease in strength due to the fire test was 72%.

SPECIMEN 1134-BB.—This column was 23 mos. old when subjected to fire and water test. It had previously withstood a load test as a portion of specimen 1134-B. When subjected to the later compression test it behaved in all respects like column 1134-CB. It withstood a total maximum load of 36 tons, or 674 lbs. per sq. in. Fig. 8 shows its appearance after it had been tested to destruction.

SPECIMEN 1134-AA.—This column was 23 mos. old when submitted for final testing. As a portion of specimen 1134-A it had withstood a load of 77.5 tons when its age was two months.

This column was enclosed in a 3-in. thickness of solid porous tile and submitted to a furnace temperature of from 1,500° to 1,600° F. for a period of three hours. It was then centrally loaded and withstood a total maximum load of 167 tons, or 3127 lbs. per sq. in., when it gave way by sudden failure. No effect whatsoever upon the column was noticed until the load was increased to 140 tons, when there was a slight falling off of the gage.

One could hardly compare the results of this

Fig. 3. Specimen 1134-CA (not exposed to fire test) after load test.

Fig. 4. Specimen 1134-AA after heat exposure; tile fireproofing removed.

Fig. 5. Specimen 1134-CB after fire test.

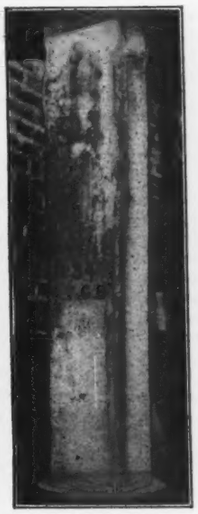

Fig. 6. Specimen 1134-CB at moment of maximum load during load test after exposure to fire.

Fig. 7. Specimen 1134-BB after fire and water exposure.

Fig. 8. Specimen 1134-BB after test to destruction.

FIGS. 3 TO 8. SIX VIEWS OF FIRE AND LOAD TEST COLUMNS.

SUMMARY OF FIRE, WATER AND LOAD TESTS OF REINFORCED-CONCRETE COLUMNS.

Material of Columns: 1 Owl Portland, 2 sand, 3 crushed limestone.
Size of Columns: 10½ × 10¼ ins., rounded corners, cross-section 106.8 sq. ins. Lengths of columns as noted in table.
Reinforcement: One ⅜-in. rod 2 ins. from each corner.
Fire Test: 1,500° F. for 3 hrs.

Number.		Length.	Tested.	Age, months.	Temperature Fahr., 3 hours.	Max. load, tons.	Max. load, per sq.in., lbs.
1134A	Made Sept 15, '04.....	12' 0"	Load, Nov. 16, '04.....	2	.....	77.5	1451
1134AA	Cut from 1134A and fireproofed Aug. 3, '06.	6' 0"	Fire, Aug. 14, '06.....	23	1500° to 1600°		
			Load, Aug. 15, '06.....		.....	167.	3127
1134AB	Cut from 1134A, Aug. 3, '06.	1' 6"	Load, Aug. 14, '06.....	23	.....	190.	3558
1134B	Made September 15, '04.	12' 0"	Load, Jan. 3, '05.....	3.5	.....	113.	2116
1134BB	Cut from 1134B, Aug. 3, '06.	5' 0"	Fire & water Aug. 14, '06.	23	1500° to 1600°		
			Load, Aug. 15, '06.....		.....	36.	674
1134CA	Cut from 1134C, Aug. 3, '06.	6' 0"	Load, Aug. 6, '06.....	23	.....	137.	2565
1134CB	Cut from 1134C, Aug. 3, '06.	5' 0"	Fire, Aug. 14, '06.....	23	1500° to 1600°		
			Load, Aug. 15, '06.....		.....	38.	711

test with that of its companion specimen 1134-AB, for the latter was too short a specimen in proportion to its dimensions.

A summary of results of all of the tests of these specimens has been prepared and is exhibited in the adjoined table.

A series of tests is now being conducted on the heat treatment of reinforced-concrete beams, and it is hoped that the results can be given to the public in a short time:

THE TWENTY-FIFTH ANNUAL CONVENTION OF THE NEW ENGLAND WATER-WORKS ASSOCIATION.

The White Mountain region is the great summer playground of New England. It was fitting, therefore, that the representative organization of New England engineers named above should celebrate its quarter-centennial by holding its annual convention in the heart of the White Mountains. The headquarters were the famous old Fabyan House, and in view of the manifold attractions of the mountain region, it was planned to make the excursions the chief feature of the convention, devoting to technical work the evenings and such daylight hours as might prove unfavorable for outdoor pleasure.

A special train of parlor cars from Boston to the White Mountains brought the majority of the members and their guests, arriving at Fabyan's on Tuesday afternoon. The number of these arrivals evidently exceeded the anticipations of the hotel management, and it became necessary to locate some of the arrivals at the Crawford House.

In order to familiarize those of the visitors who were unacquainted with the White Mountain region with its charms, Tuesday evening was devoted to a lecture by Prof. Cross of New Hampshire, finely illustrated by the stereopticon, in which the geology and topography of the White Mountain group were set forth. Two features worth special mention were a remarkable imitation with the stereopticon of the advancing sunrise, as seen from the summit of Mount Washington, and an earnest plea for effective forest preservation through Governmental action to protect the forest cover of the Granite Hills from further destruction.

On Wednesday, the entire party made the ascent of Mount Washington via the famous old rack railway, built by Sylvester Marsh in 1869, and the pioneer rack railway of the world. The summit of Mount Washington, 6,300 ft. above sea level, has a climate corresponding to that of a latitude several hundred miles farther north. Ice and sleet storms have repeatedly caused the death of those ascending the mountain on foot during the summer months. On the day in question, however, a summer temperature prevailed even on the very top, and, while the atmosphere was filled with haze which prevented a distant view, the colors of the mountain itself, with its rugged slopes and deep chasms, the sides clothed with shrubbery colored by the early frosts, made a picture of rare beauty.

In the evening after the return to Fabyan's two very interesting papers, illustrated with stereopticon views, were presented in the hotel parlors. The first of these, by Mr. Morris Knowles, described the new sand filter plant now under construction at Pittsburg under his direction as Chief Engineer of the Bureau of Filtration. Some $7,000,000 has been appropriated to carry out this work, which has become a necessity on account of the gross pollution of the Allegheny River water, which has for years given Pittsburg unenviable notoriety for a typhoid death rate higher than that of any other American city.

In Pittsburg, land and labor are both very high priced. In recognition of this—and it is believed also as a step in advance in sand filter construction—provision has been made for scraping the beds and removing and replacing the sand by machine work entirely. Thus the large court between the filter beds for the storage of sand undergoing washing, has been eliminated. To cope with the sediment carried in the water at flood time, settling basins are provided of capacity sufficient to hold 48 hours' supply for the city. The Pittsburg filters are notable also as being made up with the largest size units ever constructed.

Mr. Knowles was followed by Mr. Carleton E. Davis, late Division Engineer in Charge of the Department of Water Supply and Sewerage for the Isthmian Canal Commission, who described the work done on the Isthmus, in furnishing a good water supply to the cities of Panama and Colon and the construction camps along the line. Mr. Davis is now Division Engineer on the New Catskill Water Supply for New York City. Those who listened to his clear-cut account of what was accomplished on the Isthmus by the forces in his department, notwithstanding the difficulties, discouragement and danger incident to the outset of our Government's work there, must have awakened to the fact that the sensational newspaper accounts and criticisms on which the public has so largely formed its opinion of the work at Panama, have done a gross injustice to American engineering. The American engineers who went there to do things have, in spite of all difficulties and troubles inevitable under the circumstances, and the defects in organization, actually accomplished work deserving of highest praise.

Thursday morning's session opened with a short meeting in which a large addition was made to the list of Honorary Members of the Association, those elected being the following well-known engineers: Joseph P. Davis, Henry P. Walcott, Hiram F. Mills, Frederic P. Stearns, J. T. Fanning, Rudolph Hering, E. D. Leavitt, and Edwin Reynolds.

WORKING A PUMPING ENGINE WITHOUT AN AIR CHAMBER.

The association then took up a list of "practical experience" papers. The first of these, by Mr. Geo. A. Stacy, Superintendent of the Marlboro, Mass., Water-Works, described an experience in running a Blake 3,000,000 gallon compound duplex pumping engine, driving water through 1,500 ft. of force-main with no air in the air chamber. Some unnamed pump expert had once remarked to Mr. Stacy that this engine would run all right without any air chamber, and a slight accident caused the experiment to be tried of working the pump with the air chamber filled full of water. It should be said also that the pump was working against a head of 175 ft.

The engine worked for a day or two under these conditions and no trouble developed, although the sound in the engine room indicated considerable jar in the working. The superintendent's attention was then called to the fact that a house opposite the pumping station supplied with water by a service pipe from the force main was having serious trouble from a "chug-chug" in the pipes, similar to that sometimes caused by a tank-valve. A plumber had searched all day to find the cause of this hammering and, after he had given up and gone home, the noise stopped of itself—at the time the pumping station shut down. A house close by taking water from the same main through a similar service pipe had no water hammer.

Mr. Stacy took the incident as a warning of the strains set up in the pumps and piping system and immediately arranged to have the air chambers charged with air at the beginning of each day's run.

EXPERIENCE WITH SMALL INTERNAL-COMBUSTION PUMPING ENGINES RUNNING WITHOUT ATTENDANCE.

Mr. S. A. Agnew, Superintendent of the Scituate Water-Works, has had in operation for five years past two 16-HP. Hornsby-Akroyd oil engines, driving Smith-Vaile triplex pumps and running all day with no one in the station. One engine only is sufficient for the work and the other set is a spare for use in case of breakdown or repair. Mr. Agnew finds these engines an extremely cheap and satisfactory method of pumping for small water-works systems; but he emphasized the fact that particular care is required in looking after these engines and starting them to insure their running all day, and nothing wrong occurring. Instead of starting up the pump in five or ten minutes, he had found it advisable to spend half an hour to an hour and even longer at times, in order that any faulty working may be detected before the pump is left alone.

The most common trouble with the engine when running unattended is hot bearings, and very particular attention ought to be paid to the lubrication at every point where a plant is to run alone. A convenient way of stopping the plant automatically is to fill the oil reservoir with enough oil for the day's run, and the engine will stop of itself when the oil is used up.

At one time a smash-up was narrowly averted through the pin working out that drove the governor. The engine of course ran away. The terrific noise was heard by people near by who telephoned the superintendent. Both the engine and pump when stopped were found to have suffered no injury by this unusual performance.

An annoying and baffling source of trouble was the accumulation of balls of carbon in the vaporizer. At times the engine would work perfectly and again, with no apparent cause, a quart or two of these carbon lumps would accumulate in the vaporizer in a short time. No cause for this idiosyncrasy was ever found. The other engine of the pair never misbehaved in this way, and the bad engine was eventually replaced by another which has never showed an inclination to imitate its predecessor. If any readers of Engineering News can explain the cause of this phenomena, and how it may be obviated, it may be of interest to other oil engine operators and designers.

Concerning the economic efficiency of these oil engines, it may be said that the oil used costs only 4½ to 5 cts. per gallon in barrel lots, or a much smaller price in tank cars. A 16-HP. engine uses about 1.14 gallons of oil per hour, and pumps 9,600 gallons per hour into a 180-ft. standpipe. In regular service for a period of two months, the engine and pumps have done 12,031,000 ft. lbs. per gallon of oil.

Mr. Freeman C. Coffin remarked that he had advocated internal combustion engines for pumping in small stations for years and was gratified at the favorable experience of Mr. Agnew. Regarding troubles in the operation of these engines, most difficulty was found with oil engines, less with gasoline engines and least of all with gas engines. With the recent development of gas producers, it is quite likely that the internal combustion engine may be the coming machine for water-works pumping. At present, with gasoline engines, about 200,000 gallons per day appears to be about the place where a steam plant becomes preferable to gasoline.

Mr. Ernest H. Foster, of New York, contributed a written discussion in which he described a notable example of "pumping without attendance" at Peoria, Ill., where Mr. Dabney H. Maury has installed compound centrifugal pumps direct-connected to Pelton wheels for raising water from driven wells. The Pelton wheels are driven by water from the main pumping station and the combined efficiency of the unit is about 50%. This plant has been working since 1895.

THE ASSOCIATION'S STANDARD SPECIFICATIONS FOR CAST-IRON PIPE.

Mr. Chas. W. Sherman reported that the standard specifications for cast-iron pipe adopted by the Association had aroused great interest among engineers. In the two years since their adoption about 3,500 copies have been sold besides two orders of 1,000 each. The New American Pipe Co., of Birmingham, Ala., has adopted the specification as its standard, and sends a printed copy in reply to every request for a catalogue. The works at Lynchburg has also adopted it; but the United States Cast Iron Pipe & Foundry Co. has so far refused to book orders under it.

STANDARDS FOR FIRE HYDRANTS AND GATE VALVES.

Mr. Frank L. Fuller, for the committee on "Uniformity in the Direction of Opening Hydrants and Valves and of the Size and Shape of Hydrant and Valve Nuts," submitted a very interesting report disclosing an astonishing mix-up in these matters. There is no standard size

or shape for hydrant nuts; and wrenches that fit the hydrants of one town may often fail to fit hydrants of a town close by. So in the direction of opening; hydrants in some towns open to the right, in others to the left. In some towns the hydrants open one way and the gates the opposite way, while there are even water-works where some gates open one way and some the other. In this difficult situation the committee submitted the following recommendations:

After careful consideration of present conditions and an earnest effort to judge wisely as to the future, your Committee suggests for the consideration of the Association the following recommendations:

1. In new systems all hydrants and valves shall turn to the left to open.

2. All additions and repairs to existing systems of hydrants and valves shall be such that there shall be continued uniformity in the direction of opening, whether it be to the left or to the right. If no uniformity already exists, all new apparatus shall turn to the left to open.

(a) A city or town having an established system of water-works should continue to install hydrants and valves having the same operating nuts and opening in the same direction as those already in use, unless it has been decided to at once change all old hydrants and valves to the new standard. This principle is imperative and no departure should be made from it. It is unfortunate that entire uniformity was not earlier advocated and adopted. The very rapid increase in water-works appurtenances, great numbers being turned out daily, increases the importance of uniformity.

3. All fire hydrants shall have a pentagonal (five-sided) operating nut finished without taper to 1½ ins. from "point to flat." The nut socket in the wrench shall be made without taper so as to be reversible.

(a) This size and shape of nut is in quite general use and has been recommended by the National Fire Protection Association.

4. An arrow at least 6 ins. long, showing the direction of opening and the words "to open" in distinct letters at least ¾-in. high, shall be cast with ⅛-in. relief, upon the top of all fire hydrants.

5. All valves connected with street mains shall have an operating nut $1^{15}/_{16}$ ins. square at the top, 2 ins. square at the base, and 1¾ ins. high.

6. The operating nut on all valves shall be made with a flanged base upon which shall be cast an arrow, at least 2 ins. long, showing the direction of opening and the word "open" in distinct letters at least ⅛-in. high, as shown in the sketch.

The standard direction for opening hydrants and street valves is a perplexing question and there are sure to be differences of opinion. The standards recommended are for new systems and for such others as choose to change. It will be many years before entire uniformity can be secured and then only by the earnest cooperation of those who believe uniformity to be worth striving for.

The discussion of the report developed that no standard had been recommended by the committee for the auxiliary or independent valves of fire hydrants, and the report was referred back to the committee for further investigation. Mr. C. W. Sherman mentioned that in a water-works under his direction where some valves opened one way and some the other, the Superintendent had been instructed to paint an arrow on the under side of each valve-box cover to show the direction of opening. Mr. Coffin suggested that where a few valves on a works open the reverse way from the majority, gearing could be applied to reverse the movement of the valves and uniformity thus secured. Mr. Blake, of the Pitometer Co., reported that in recent investigations with the Pitometer, cases had been found where no water was flowing in mains, and the cause had been found to be gates tight closed that had for years been supposed to be opened, they being right handed gates instead of left handed as supposed, or the reverse.

The morning session closed with the announcement by President Sedgwick of a nominating committee made up of Messrs. Brackett of Boston, Whipple of New York, French of Boston, Metcalf of Boston and Hammond of Rockville, Conn.

DIFFICULT SUBAQUEOUS TUNNEL WORK.

The Thursday evening session opened with an account by H. W. Spooner, of the Gloucester Water Department, of building a short tunnel to carry water and gas pipes under a narrow canal. The tunnel was of small size and only about 150 ft. in length, but it was made through freely water-bearing gravel containing boulders of all sizes up to 10 or 12 ft. in length. The tunnel was driven by contract, and after other methods had been tried and failed compressed air was used. The air was held by plastering all working faces with clay and excavating with trowels with the greatest care and watchfulness to prevent blowouts. The tunnel was brick lined, and to lessen the difficulties due to varying water pressure at top and bottom, the upper half of the tunnel was driven first and the arch put in. Later the lower half was taken out and the invert built.

A LARGE REINFORCED CONCRETE STAND-PIPE.

At Attleboro, Mass., the largest reinforced concrete stand-pipe yet built was erected a year ago, under Mr. Geo. H. Snell as Water Commissioner, with Messrs. Snow & Barbour as Consulting Engineers, and the Aberthaw Construction Co., of Boston, as contractors. A very valuable account of this work was given by Messrs. Snell and Barbour and Mr. L. C. Wason, President of the contracting firm. The stand-pipe is 100 ft. high and 40 ft. in diameter and was erected at a contract price of $34,000, the best bid for a steel stand-pipe being $37,500. The lower cost, however, was not the chief advantage or reason for adopting the reinforced concrete structure. The Attleboro water, while pure from a sanitary standpoint, has a corrosive effect on iron, and from the old steel stand-pipe of much smaller size over two tons of scale was removed annually. The safe life of a steel stand-pipe would not be over 20 years, while the concrete pipe should last indefinitely. The Attleboro stand-pipe is a success and should form an important precedent for the erection of other structures of this sort. It is true that some minor trouble has been experienced with leakage at a few points where concrete was not of the high quality aimed at; but these have been effectively remedied. The stand-pipe is now receiving the final coats of waterproofing by the Sylvester process.

Discussion on these interesting papers was impossible on account of the lateness of the hour.

FRANCONIA NOTCH EXCURSION.

The weather is a vitally important factor in the movements of an excursion party in the mountains. Wednesday and Thursday were warm, showery and hazy. Friday dawned clear and cool, an ideal day for pleasure, and it was devoted to an excursion to the Franconia Notch, where Profile Lake, Echo Lake, the famous Flume and Bald Mountain were the chief objects of interest to the visitors. On the return from the excursion many of the party took the evening trains homeward.

Those remaining attended the closing session, which was devoted to sanitary matters. Mr. Geo. C. Whipple, of New York, contributed a paper describing the prevalence of typhoid in Cleveland during years past, and particularly during 16 months of 1903-4. The cases of typhoid in the city during this time were several thousand in number. Careful examinations carried out by Mr. Whipple at the instance of Prof. Bemis, the Superintendent of the Water Department, showed that the pollution of the lake water by the city's sewage, particularly that carried out by the foul Cuyahoga River, was chiefly responsible for the epidemic. Changing the source of water supply to the new intake crib four miles out in the lake put a stop to the epidemic.

The final paper of the session and of the convention was by the President, Prof. Wm. T. Sedgwick, on the prevention of a city's watershed from pollution during the construction, maintenance and operation of a railway line across it. The paper had particular reference to the Cedar River drainage area supplying the city of Seattle, Wash. Some account of this very remarkable piece of sanitary work was given in our issue of Aug. 30.

IRON IN CHINA is made by mixing four parts of the ore, one part of decomposed coal dust, and one part of small coal. The mixture is placed in crucibles each about 18 ins. deep and 6½ ins. in diameter. The crucibles are heated in a furnace having walls about 3 ft. high and a floor 4 × 6½ ft. which is covered with clay and spread with a layer of coarse coal to a height of 7 or 8 ins. above the clay. The furnace holds about sixty of these crucibles. The space between them is filled with small coal and on top is placed a 3-in. layer of small coal followed by a layer of cinders and ashes of the same depth. About 16 hrs. of strong heat suffices to convert the mixture into a mass of carbon iron. This is made into wrought iron by reheating over a wood fire and by hammering it when red hot.

LONGITUDINAL DISPLACEMENT OF THE SUSPENDED STRUCTURE OF THE WILLIAMSBURGH BRIDGE, AT NEW YORK, N. Y.

Newspaper articles published within the last two weeks, bearing startling headlines such as "The Williamsburgh Bridge Slipping to Brooklyn," told that the second bridge across the East River has shifted from the position where it was first put, and that the movement is progressive, and hinted that unless soon corrected this condition meant serious danger to the bridge. These reports, we have no doubt, were promptly discredited by engineers who read them, at least as concerns the suggestion of danger involved. Yet they must have created much curiosity as to what was back of these news reports, and what really ailed the Williamsburgh Bridge. The following statement, drawn up on the basis of material furnished us by the Department of Bridges of New York, may therefore be of interest to many of our readers.

Some time ago it was noticed, in the course of the regular maintenance inspection, that the end shoes at the Williamsburgh (Brooklyn) end were somewhat closer to the back of the bridge seat than those at the Manhattan end, the difference being not quite constant, but amounting to several inches. In May of the current year an experiment was made to shove the bridge into central position. At that time the difference of the end clearances amounted to just 3 ins. Blocking and jacks were put between the Brooklyn end shoes and the stonework, and on applying pressure the suspended structure (trusses and roadway) moved westward easily. It is estimated by the engineers in charge of the bridge that a total force of but 6 to 8 tons was brought into play. When the central position was approximately reached the jacks and blocking were removed and the bridge was again left to itself. Soon it became evident that the clearances again differed by small amounts, and as the summer went on the displacement grew larger. The shoving had brought the structure within $^1/_{16}$-in. of a truly central position, the residual being a displacement toward Brooklyn. At the present time (September 17) the clearances differ $1^7/_{16}$ ins., in the same direction. There seems to be no reason to apprehend any considerable increase in the shift. The clearance between steelwork and stone abutment is ample, and, while there could be no bad result if the steel at the Brooklyn end were to come to bearing against the abutment, the clearance could be increased with little trouble, at relatively small expense. The base-plates under the roller bearings are stated to be long enough to give ample margin over the extreme actual expansion changes even in the one-sided position. In the roadway and the railway tracks, the existing expansion provisions are ample to care for the displacement.

For explanation of the occurrence we may recall the fact that the Williamsburgh Bridge differs markedly from its predecessor, the Brooklyn Bridge, in the arrangement of its stiffening trusses. In the latter the trusses are fixed at the towers and have numerous hinges and sliding joints, and the trusses of the main and the shore spans are independent. In the Williamsburgh Bridge each of the two stiffening trusses is a continuous framework from anchorage to anchorage, without expansion joints and without hinge-pins; the suspended structure is supported by a rocker-arm bearing under the middle of the roadway at each of the two main towers, and by a roller bearing under each truss at either anchorage and at the tower in the middle of either shore arm. In effect, therefore, it rests on six movable bearings and has nothing to fix its longitudinal position except the tendency of the suspenders to hang vertically under the pull of the supported weight. Now, as temperature changes occur, the bridge structure expands, and the trusses must consequently move lengthwise on their bearings. If all the bearings offer equal resistance to motion, the expansion will take place from the middle toward each end in equal measure, creating a certain longitudinal force at each of the three bear-

ings on either side; but if the bearings on one end should have somewhat greater friction than those on the other end, the resulting motion would be greater toward one side of the river, as may be readily understood. If the principal abnormality of friction occurred at only a single one of the bearings instead of being distributed over all three bearings of one end, the distribution of the expansion and contraction would be somewhat complex.

In the case of the Williamsburgh Bridge these latter are precisely the conditions: one of the bearings at the Manhattan or west anchorage (north truss) is not in good order and in consequence has a friction greater than that of any one of the other bearings. It is a roller bearing of the customary construction, the rollers being confined between a steel base-plate and a cast-steel shoe and held at their sides by two longitudinal spacing-bars. Two years ago it happened that, for purposes of cleaning, the spacing-bars were taken off the rollers of this bearing and by inadvertence were left off over night. When the workmen came to replace them the following day they replaced the one spacing-bar properly but were unable to get the other over the ends of all the pins; they therefore jammed it on as well as they could, leaving the rollers toward one end unconnected to that spacing-bar. These rollers are very slightly skewed and do not give the bearing perfectly free motion. Apparently they permit a certain amount of motion without materially greater friction than normal, but not a sufficient amount to allow for the full expansion. The result is that the surplus expansion all goes toward the Brooklyn end, creating the asymmetrical condition described. Similarly, no doubt, in winter the surplus contraction will come from the Brooklyn end. The longitudinal restoring force due to the inclination of the suspenders from the vertical for the maximum observed displacement toward Brooklyn is too small to correct for the friction force at the Manhattan end bearing. Yet the total "tractive resistance" of the bridge on its movable bearings is not large, as was found during the longitudinal jacking last May.

We understand that plans are already completed for overhauling the bearing in question. Jacks are to be put under the bottom chord of the truss, after putting in blocking and timber braces sufficient to transfer the lifting force to the main panel points; when the load has been taken off the rollers by the jacks, the rollers are to be taken out, cleaned, and the bearing re-assembled in good order.

THE PENNSYLVANIA R. R. HUDSON-RIVER TUNnel reached the end of the first stage toward completion on Tuesday, Sept. 11, at which time the headings met in the north tube of the tunnel. The headings had been advanced continuously from both shores, by shield working, and the point of meeting was near the middle line of the river. An opening through the two shields was made in the afternoon of Sept. 11, and on the following day a celebration party went through the tunnel from the Weehawken (New Jersey) to the New York end. The tunnel is being built under the direction of Mr. Charles M. Jacobs by the O'Rourke Engineering Construction Co. The contract was let on May 2, 1904. The railroad company had, to hasten the tunneling operations, constructed the main shafts at the two ends complete, with concrete lining, so that as soon as the tunnel contract was signed the contractor was in a position to proceed with driving the headings. The New York shaft was ready at the time, but the Weehawken shaft could not be turned over to the tunnel contractor until September, 1904, making a delay of four months at that end. As the distance between shafts is about 6,500 ft., the average rate of advance has been 8 ft. per day, or 4 ft. per day per heading. Not all of this was shield work, as the shield-chambers, in which the shields were erected, are 325 ft. and 224 ft. out from the shafts on the New York and New Jersey sides respectively. The tunnel comprises two tubes, parallel and on the same level throughout. Its grades are 1.92% on the New York side and 1.30% on the New Jersey side. Each tube is circular, 23 ft. in diameter over the shell. The shell is a cast-iron (in some places cast-steel) sectional tube, which later is to be lined with 2 ft. of concrete. Special "bore" segments in the bottom, every 15 ft., make provision for later sinking metal screw-piles through the bottom of the tunnel to rock, in order to prevent all possibility of disturbance of the structure from the effects of operating heavy trains at high speed through the tunnel. The cast-iron shell was, as usual, placed inside the tail of the shield as the latter advanced. None of the concrete lining is in place as yet.

A TRAIN DERAILMENT ON A BRIDGE on the Chicago, Rock Island & Pacific, near Guthrie, Okla., on Sept. 18, destroyed an entire train and probably killed several people, though no positive information on this point is yet to be had. A bridge over the Cimarron River had been shifted out of line, it is stated, by the pressure of drift brought down by high water. A northbound passenger train, running fast to make up time, ran upon the bridge before the engineer noticed the condition of the structure, and wrecked the latter; all of the train but two Pullman cars fell into the river.

THE COLLAPSE OF A CONCRETE BUILDING during construction, at Mineola, L. I., on Sept. 10, killed two men. The building was to be an automobile storage building, two stories high, and the walls had nearly reached full height at the time of the accident. The collapse is charged to the quality of the concrete used in the walls. The contractors for the work, Geo. A. Varney & Co., of New York, claim to have found much difficulty in getting suitable sand in the neighborhood.

A BAD RAILWAY ACCIDENT occurred on the Canadian Pacific Ry. near Axilda, Ont., on the morning of Sept. 12. An eastbound and a westbound passenger train collided at a passing point, and a dozen persons were killed. Both trains were running in several sections, and the westbound train carried a large excursion crowd. The wreck was caused by the brakes on the heavy diner and sleepers failing to work, according to the statement of General Manager McNicoll. An "angle cock" at about the middle of the train had in some way been closed, thus making the brakes of rear coaches useless.

AN INTERNATIONAL WIRELESS TELEGRAPH Congress will be held in October at Berlin, with delegates representing all the leading European nations, the United States and Japan in attendance. Questions regarding the international regulation of wireless traffic, its control in times of war and peace, etc., will be discussed.

THE OVERSEAS LIMITED, the new train of the Canadian Pacific Ry. (Eng. News, p. 264, Sept. 6, 1906), on its initial trip completed the run on schedule time, covering the 3,070 miles between Quebec, P. Q., and Vancouver, B. C., in 96 hrs.; arriving at Vancouver on Sept. 5. The trip from Liverpool to Quebec, a distance of 2,633 knots (3,028 miles) was made in 6 days, 7 hrs., 50 min.; 6 hrs. and 10 min. quicker than any previous record for this route. If the schedule is maintained in crossing the Pacific the 6,271 knots (7,212 miles) will have to be covered in 18½ days, making a total of 29 days required to cover the 12,000-mile journey from Liverpool to Hong Kong.

THE LONG GRAVITY WATER SUPPLY CONDUIT projected for Los Angeles, Cal., is to be studied and reported on by a board of engineers consisting of Messrs. F. P. Stearns, Boston, Mass; J. D. Schuyler, Los Angeles, Cal., and John R. Freeman, Providence, R. I. As proposed, the conduit will be considerably more than 340 miles in length, passing over the Mojave Desert and through the San Fernando Mountains, the latter in a long tunnel. The development of a large amount of horse-power to be converted into electric energy and transmitted to Los Angeles is proposed. Mr. J. B. Lippincott, M. Am. Soc. C. E., recently severed his long connection with the U. S. Geological Survey to carry on investigations in connection with this project. Mr. William Mulholland is superintendent of the Los Angeles water-works.

PERSONALS.

Mr. John N. Kerr, Assistant Engineer of the Reclamation Service, has resigned.

Mr. W. M. Vandersluis has been appointed Signal Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Ry., with headquarters at Cincinnati, O., to succeed Mr. G. H. Macdonough, resigned.

Mr. C. W. Swearingen has been appointed City Engineer of Great Falls, Mont. He formerly held the same position, but resigned in May, 1903, to superintend the installing of a system of water works, sanitary sewers and general municipal improvements at Havre, Mont.

Mr. Richard S. Buck, M. Am. Soc. C. E., Consulting Engineer, Department of Bridges, New York City, has been admitted as a member of the firm of Sanderson & Porter, Engineers and Contractors, of New York City. Mr. Buck will continue to act as Consulting Engineer to the Department of Bridges for the present.

Mr. F. M. Spaidel, Division Superintendent of the Canadian Pacific Ry. at Smith's Falls, has resigned. He will be succeeded by Mr. J. A. Vaughan, Superintendent of Terminals at Montreal. Mr. R. W. McCormick, Trainmaster at Ottawa, has been made Assistant Superintendent at Smith's Falls and is succeeded as Trainmaster at Ottawa by D. Robertson.

Col. Wm. S. Stanton, Corps of Engineers, U. S. A., has been placed on the retired list of the army on account of age. Col. Stanton had, until recently, been in charge of the river and harbor works about Boston, Mass. His retirement has brought about the following promotions in the Corps of Engineers: Lieut.-Col. Ernest H. Ruffner has been made Colonel; Major Frederick V. Abbot, Lieutenant-Colonel; Capt. Wm. W. Harts, Major; First Lieut. Curtis W. Otwell, Captain; Second Lieut. Thomas M. Robins, First Lieutenant.

Mr. R. E. Mathot, M. Am. Soc. M. E., the well known gas expert of Brussels, Belgium, will spend some time in the United States next November. He has published several articles on gas engines and producers, among which was "The Growth of Large Gas Engines on the Continent," read at the Liege meeting of the Institution of Mechanical Engineers of Great Britain, 1905. (Eng. News, Aug. 31, 1905, p. 216.) His headquarters while in this country will be, the American Society of Mechanical Engineers, 12 W. 31st St., New York City.

Obituary.

Johns Simonds, President of the Simonds Saw Co., of San Francisco, died Sept. 9, at Berkeley, Cal.

William Flanagan, a contractor of Brooklyn, N. Y., died at his home in that city, Sept. 11, aged 69 years.

Warren G. Elliott, President of the Atlantic Coast Line R. R. of Connecticut, died at Watkins Glen, N. Y., Sept. 17, of kidney disease, aged 58 years.

Clarence K. Wooster, Third Vice-President of the People's Gas, Light and Coke Co., of Chicago, Ill., committed suicide Sept. 9, by cutting his throat. He was 49 years of age.

Daniel O'Day, Vice-President of the National Transit Co., a subsidiary company of Standard Oil, died at Royan, France, Sept. 13. He built the first pipe line for carrying oil in 1873, and since then had been connected with the transportation end of the oil business.

Daniel Heald Wood died at Montclair, N. J., Sept. 12, aged 84 years. Mr. Wood had been connected with the biuilding of several railroads as engineer, viz., the Vermont Central R. R., the Syracuse & Binghamton Railroad, the New York & Oswego Midland R. R., and the New York, Susquehanna & Western R. R.

Edmund R. Willson, an architect of Providence, R. I., died at Petersham, Mass., Sept. 9, of Bright's disease. He was born at Salem, Mass., April 21, 1856, and was a graduate of Harvard, class of 1875. He had also taken graduate work at the Massachusetts Institute of Technology and the Ecole de Beaux Arts, Paris. Mr. Willson was a member of the American Institute of Architects.

George Tatnall, M. Am. Soc. C. E., Principal Assistant Engineer of the New York, Westchester & Boston Ry., died Sept 13, at Lynn, Mass., from injuries received Sept. 7 by the premature explosion of a charge of "ferrone," a new explosive. He, with Mr. F. W. Wartenberger, the inventor, was giving a demonstration of the explosives' uses, when, from some unknown cause, the charge with which Mr. Wartenberger was loading a hole prematurely exploded, fatally injuring both men. Mr. Wartenberger died the evening of the accident, while Mr. Tatnall lingered a week. Mr. Tatnall was formerly connected with the Engineering Department of the Pennsylvania R. R., and was a native of Wilmington, Del.

ENGINEERING SOCIETIES.

COMING MEETINGS.

LEAGUE OF AMERICAN MUNICIPALITIES.
Sept. 26 to 28. Annual convention at Chicago, Ill. Secy., Jno. MacVicar, Des Moines, Iowa.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 2 to 5. Annual Meeting at Birmingham, Ala. Secy., G. W. Tillson, Municipal Bldg., Brooklyn, N. Y.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 8-9. Annual meeting at New York City. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

AMERCAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 15 to 19. Annual Convention at Columbus, Ohio. Secy., Bernard V. Swenson, 60 Wall St., New York City.

THE RAILWAY SIGNAL ASSOCIATION.
Oct. 16-18. Annual Meeting at Washington, D. C. Secy., H. S. Balliet, Grand Central Station, New York City.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION OF AMERICA.
Nov. 13-15. Annual Meeting at Chicago, Ill. Secy., C. E. Jones, Beardstown, Ill.

AMERICAN MINING CONGRESS.
Nov. 13-17. Annual Meeting at Denver, Col. Secy., J. F. Calibreath, Jr., Denver, Colo.

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